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INSTRUCTION MANUAL
HGA

California INSTRUMENTS

Invertron® AC POWER EQUIPMENT

MP MASTER
MA28088

California Instruments Corporation

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California Instruments

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INSTRUCTION MANUAL
HGA

Invertron®

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HGA MANUAL ERRATA

CAUTION

The programmed value for the voltage must be reduced if the TRMS value of the harmonic voltages are above the maximum frequency of the power source. A reduced voltage, 0 to 50%, must be maintained when switching the waveform back to sine wave for 0.05 seconds or more

The TRMS value of the harmonic voltage can be calculated from the following formula:

$$V_{trms} = \sqrt{(V_1^2 + V_2^2 + V_3^2 + - -- V_n^2)}$$

Where V_1 through V_n are the RMS values of the respective harmonic voltages. If the values are in %, V_{trms} will also be in %.

V_{trms} must be less than 50% of the full scale voltage for the respective voltage range if the harmonic frequencies exceed the maximum frequency of the power source.

A power system is comprised of one or more power sources. The maximum frequency of the power systems is given in the following table:

POWER SOURCE AND SYSTEMS	MAXIMUM FREQUENCY (HZ)
4500L-3 without MODE option	5000
Any system with 4500L or with MODE option	2000
4500L-1 with 555 option	67
Any system with 6000L-1 or 3	440
Any system with 6000L-1 and 555 option	67

HGA
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APPENDIX

APPENDIX	DESCRIPTION
A	HGA Graphical User Interface Training Manual

SECTION 1

INTRODUCTION AND SPECIFICATION

1.0 INTRODUCTION

This instruction manual contains information on the installation, operation, calibration, and maintenance of the HGA with an AC source system. The AC source instruction manual should be used only when the HGA manual refers to the AC source manual.

1.1 GENERAL DESCRIPTION

The HGA is a waveform, harmonic and transient generator producing with a complete measurement subsystem. The HGA will interface with many AC power sources to produce a programmable power system with harmonic generator and harmonic analyzer.

The HGA gives an AC power source the following capabilities

- Programmable AC voltage, Frequency, Phase Angle (3-phase system) and Current Limit.
- Sine, Clipped sine, user defined waveforms and square waves (if capable by the AC source).
- Voltage and Frequency slew control.
- Synthesized waveform generation with high resolution, accuracy and low distortion.
- Step and Pulse output transients for generating surge, sag, dropout and other line disturbance simulation.
- Programmable lists for generation of complex output transients or test sequences
- Extensive measurement capabilities of:

    AC rms Voltage and Current

    Peak Current

    Real and Apparent Power

    Harmonic analysis of voltage and current up to the 49th harmonic

    Total harmonic distortion calculation

- Trigger transient on phase angle or external bus command.
- External source synchronization.
- External Voltage Amplitude Modulation
- Nonvolatile state and waveform storage
- IEEE488 and RS232 Interface with SCPI command language.
- Over and under voltage, overcurrent and overtemperature shutdown.
- Remote shut down signal input
- Software Calibration.

ARBITRARY WAVEFORM GENERATOR/CONTROLLER SPECIFICATION

ELECTRICAL

Input (Nominal line voltage, 50 or 60 Hz, unless specified otherwise)

Line Voltage	103 - 127 VAC, 207 - 253 VAC user selectable
Line Current	0.5A/0.25A (1 amp fuse)
Line Frequency	47 - 63 Hz
Isolation Voltage (input-chassis)	1350 VAC

Refer to the AC source specification for its input specification.

Output (when used with external amplifier)

Number of Phases	1 or 3
Voltage Range	0 to 312V
Total Harmonic Distortion	Refer to AC source Output specification
Line Regulation (10% change)	2%
Load Regulation (100% load change)	0.5 %
Voltage Accuracy	0.4 %
Voltage stability	±0.25% over 24 hrs, constant line, load and temperature.
Fundamental Frequency Range	45 - 66 Hz
Frequency Temperature Coefficient	±5 ppm
Frequency Stability	±15 ppm of value per year

Protection

Refer to AC source protection specification

Measurements (23°C ±5°C)	Range	Resolution	Accuracy
Voltage	0 - 312V	0.1V	0.5V
Current	0 - 16A	0.01A	0.05A
	0 - 160A (Opt)	0.1A	0.5A
Peak Current	80A	0.02A	2.4A
	800A (Opt)	0.2A	24A
Power	0 - 4kW	0.001kW	0.005kW
	0 - 40kW (Opt)	0.01kW	0.05kW
Apparent Power	0 - 4kVA	0.001kVA	Not specified
	0 - 40kVA (Opt)	0.01kVA	Not specified
Power Factor	0 - 1	0.001	Not specified
Frequency	45 - 66Hz	0.01Hz	0.02Hz
Phase Angle (at V > 20)	0 to 359°	0.1°	2°
Individual Harmonic Voltage	0 to 312V	0.1V	1.0V

Measurements (23°C ±5°C)	Range	Resolution	Accuracy
Individual Harmonic Current	0 to 16A	0.005A	48mA
	0 to 8A	0.003A	24mA
	0 to 4A	0.002A	12mA
	0 to 2A	0.001A	6mA
	0 to 80A (Opt)	0.03A	240mA
	0 to 160A (Opt)	0.05A	480mA
Total Harmonic Distortion (Voltage and Current)	0 - 100%	0.1%	1%
Harmonic Bandwidth	2nd to the 49th harmonic for a fundamental frequency of 45 to 66 Hz		
Harmonic Measurement Time	8 seconds (to measure all harmonics)		

Control

Front Panel Control

Voltage, Frequency, Current Limit, Listen Address and single-phase/three-phase. All phases are programmed simultaneously. Measurement of voltage, current, power, and frequency.

Function Selection Keys	Set, measure, voltage, freq, current, power, utility, execute, cursor control and numerical control knob.
Display	2 x 16 Backlit LCD, 4.8mm x 9.6mm character size
Indicators	Power On, Remote

Computer Control

I. IEEE-488.1 (GPIB)

Subset:

SH1, AHI, T6, L3, SR1, RL1, DC1, DT1

Code and Format:

Conform and Support Common Commands defined by IEEE-488.2

II. RS232

1. Data Format
   Same as GPIB
2. Baud Rate
   Up to 9600 bauds

III. Language

SCPI (Standard Command for Progrmmable Instruments)

IV. Functions (with L Series Power System)

	Range	Resolution	Accuracy	Initialization
Voltage	0 to 312 Vrms	0.1V	0.4%	00
Frequency	45 to 66 Hz	0.01Hz	.005%	60 Hz
Phase Angle	0 to 360°	1°	2°	0 to 360
Harmonic Distortion				
(Flat Top)	0 to 20%	1%	2%	0%

Single/Multiple Harmonic Voltage Generation 2-49th (for a fundamental frequency of 45 to 66 Hz). Any harmonic may be programmed from 0 to 100%.

Transient: Use the List, pulse or step subsystem for voltage, frequency, current limit and phase angle transient with slew capabilities for both voltage and frequency.

Waveform files down loaded:

Ability to store up to 18 downloaded waveforms 4096 points each.

Programmable transient start point.

Calibration	Measured voltage, current, power, harmonic voltage, harmonic current and output phase angle.
Diagnostics (Self Test)	Ram Test, ROM sum check
Storage	Store up to 4 steady state setups
Status Byte	IEEE488.2 Status Subsystem

External Control

Modulation	0 to 10Vrms = 10% amplitude modulation, DC to 550 Hz, simultaneous on 3ø system
Shutdown	Logic low
Sync Input	TTL waveform to sync phase A output. Output frequency locks to the input sync from 45 Hz to 66 Hz.
Output Signals:	Sync output, TTL output active high for 500 usec, 1.5 mA sink to indicate the beginning or end of transient.

Features

- Remote Sense
- Calibration of measurement and output phase offset - from Computer Bus
- Output Relay control - from Computer Bus
- Current Limit/Current Limit Delay

Options

High Current range - 160A
Single/Three-phase Programmable
Drop out switch (Independent output dropout for each phase)

Systems

Compatible with California Instruments Models 4500L, 2750L, 1501L, 751L, 3001TCA and FCS series. Consult factory for other compatible manufacturers' AC power sources.

MECHANICAL (HGA controller only)

Dimensions	3 1/2"(88.9mm)H x 17"(431.8mm)W x 22"(558.8mm)D
Weight	35 lbs.(15.9Kgm)
Material	Steel
Finish	Zinc Plate, Front Panel Gray paint
Air Intake/Exhaust	Sides/Rear
Connectors	
- Input	IEC320-C14 AC Receptacle
- Sense	1-480705-0 AMP
- AC Power Source Interface	3M3367-1000
- IEEE/488	3M3549-1000
- RS232	9 Pins DB9 male
Chassis Slides	General Devices C300S-118-U/B308BKT

Refer to AC power source user manual for AC source Mechanical specification.

ENVIRONMENTAL

Operating Temperature	0 to 50°C
Storage Temperature	-40 to +85°C
Operating Altitude	7500 ft.
Vibration	Commercial transportation levels
Shock	Commercial transportation levels
Acoustic Noise	65 dBA, 3 ft.

Refer to AC power source user manual for AC source Environment specification.

SECTION 2

INSTALLATION AND ACCEPTANCE

2.0 UNPACKING

Inspect the unit for any possible shipping damage immediately upon receipt. If damage is evident, notify the carrier. DO NOT return an instrument to the factory without prior approval. Do not destroy the packing container until the unit has been inspected for damage in shipment.

2.1 POWER REQUIREMENTS

The HGA has been designed to operate for single-phase AC line voltage. The HGA can operate from input voltage line from 103 volts to 127 volts in the 115 voltage range or from 207 volts to 242 volts on the 230 volt range. The input line frequency may be between 47 Hz and 66 Hz.

Refer to AC source manual Section 2 for power requirements for the AC source.

2.2 MECHANICAL INSTALLATION

The HGA is designed for rack mounting in a standard 19 inch rack. The unit should be supported from the sides with optional rack slides. Refer to Section 1, under Mechanical specifications for the proper chassis slides. The cooling fan at the rear of the unit must be free of any obstructions which would interfere with the flow of air. A 2.5 inch clearance should be maintained between the rear of the unit and the rear panel of the mounting cabinet. The air intake holes on the sides of the HGA must not be obstructed. See Figure 2.1

2.3 CONNECTIONS

2.3.1 INPUT WIRING

Refer to Figure 2-2 for the HGA rear panel connections.

The HGA Input connector uses a standard IEC320-C14 AC Receptacle. The HGA operates from nominal 115 volts AC or 230 Volts AC. To change the input voltage range, locate F1 power input selector on the rear panel. Pull out the printed circuit board located under the fuse. Rotate the printed circuit board and insert it so that the desired voltage range is shown when the board is in its place. Do not use other voltage range positions except the 120 and 240 volts selections.

Refer to AC source manual Section 2 for input wiring for the AC source.

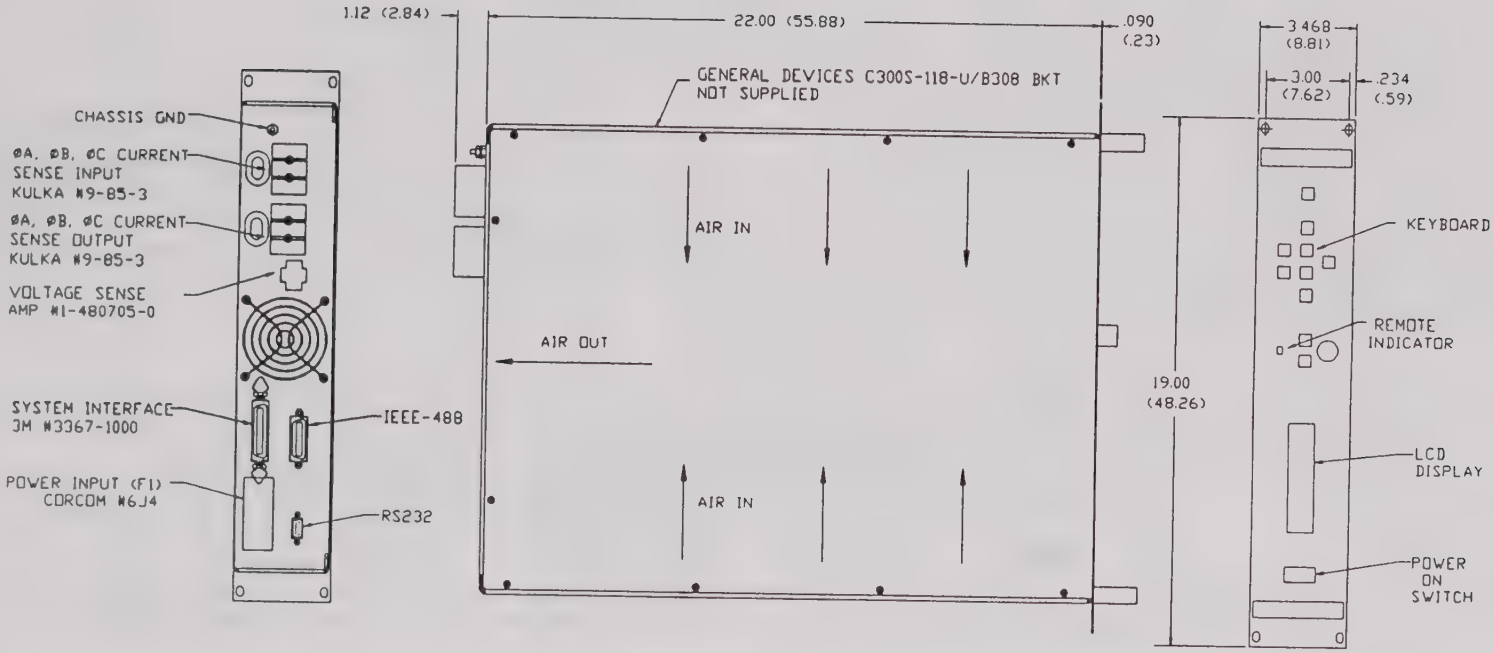
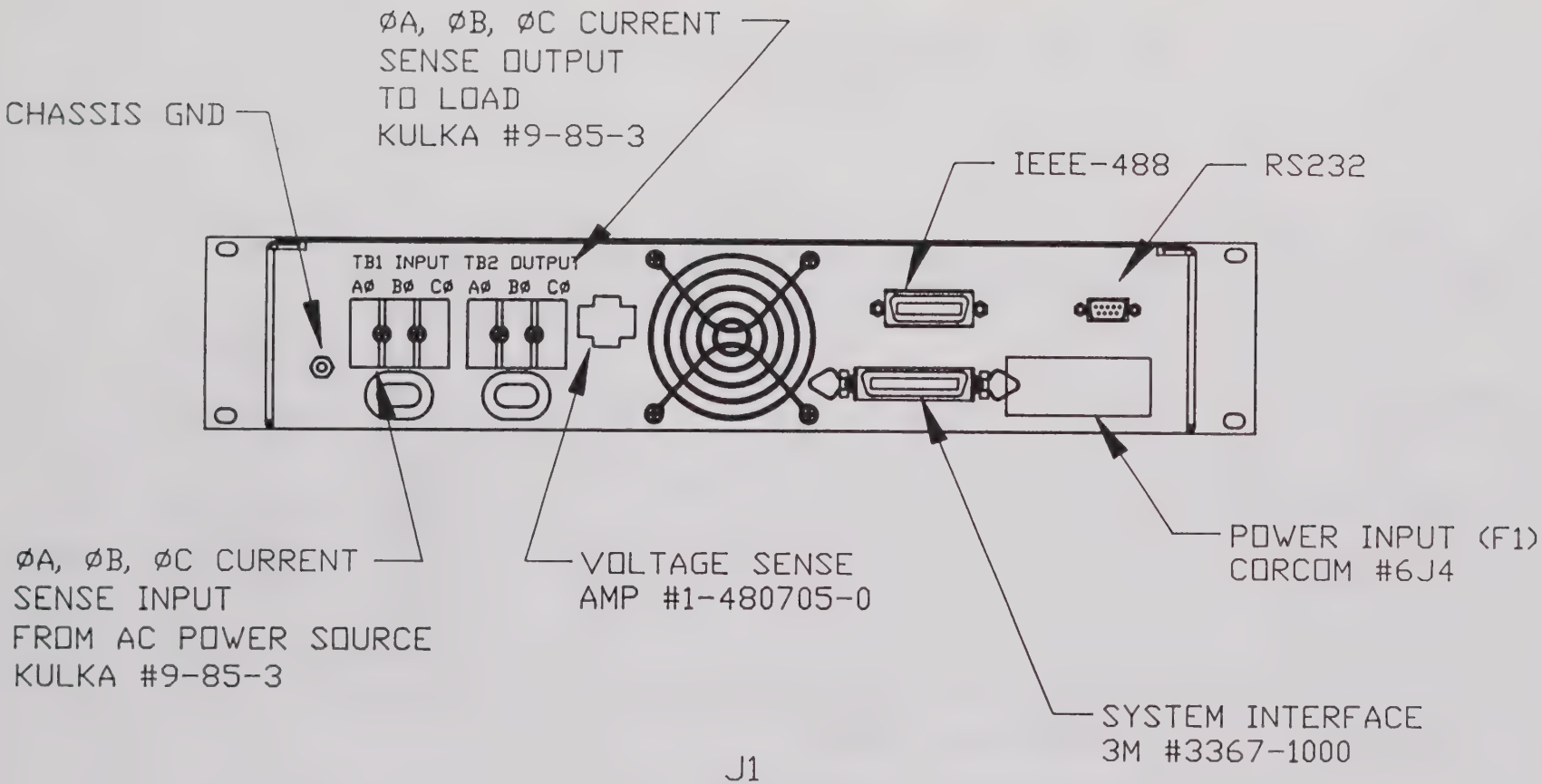


FIGURE 2-1
CALIFORNIA INSTRUMENTS HGA



J1

PIN	FUNCTION
1	A SENSE
2	B SENSE
3	C SENSE
4	NEUT SENSE

FIGURE 2-2
REAR PANEL CONNECTIONS

2.3.2 CURRENT SENSE TERMINAL BLOCK

Figure 2-1 shows the overall view of the HGA.

The output of the AC source is routed through the HGA to sense the current. TB1 terminal block connects to the output of the power source in use, and terminal block TB2 is the output terminal that connects to the load. Refer to the AC power source manual in use with the HGA for the correct wire size and length. Refer to Figures 2-3-1 through 2-3-10 for the proper connections with various power sources.

2.3.3 EXTERNAL SENSE

To ensure correct voltage regulation, the sense input must be connected to either the load or the output of the AC source.

J1 is the external sense input connector. The external sense input must be connected to the output of the AC source or to TB2 of the current sense terminal block. If the sense inputs are not connected to the output of the AC source or the load, the output voltage will fault.

The following table identifies the pins of J1 connector and the proper connection.

1-phase A sense HI	phase A output HI
2-phase B sense HI	phase B output HI
3-phase C sense HI	phase B output HI
4 Neutral sense	Neutral output

(Low output for single phase power source)

2.3.4 IEEE-488

J2 is the IEEE-488 (GPIB) connector for the HGA.

2.3.5 RS232

J4 is the RS232 connector for the HGA.

Refer to the Tables 2-1 and 2-2 for the proper connection between the HGA and the personal computer.

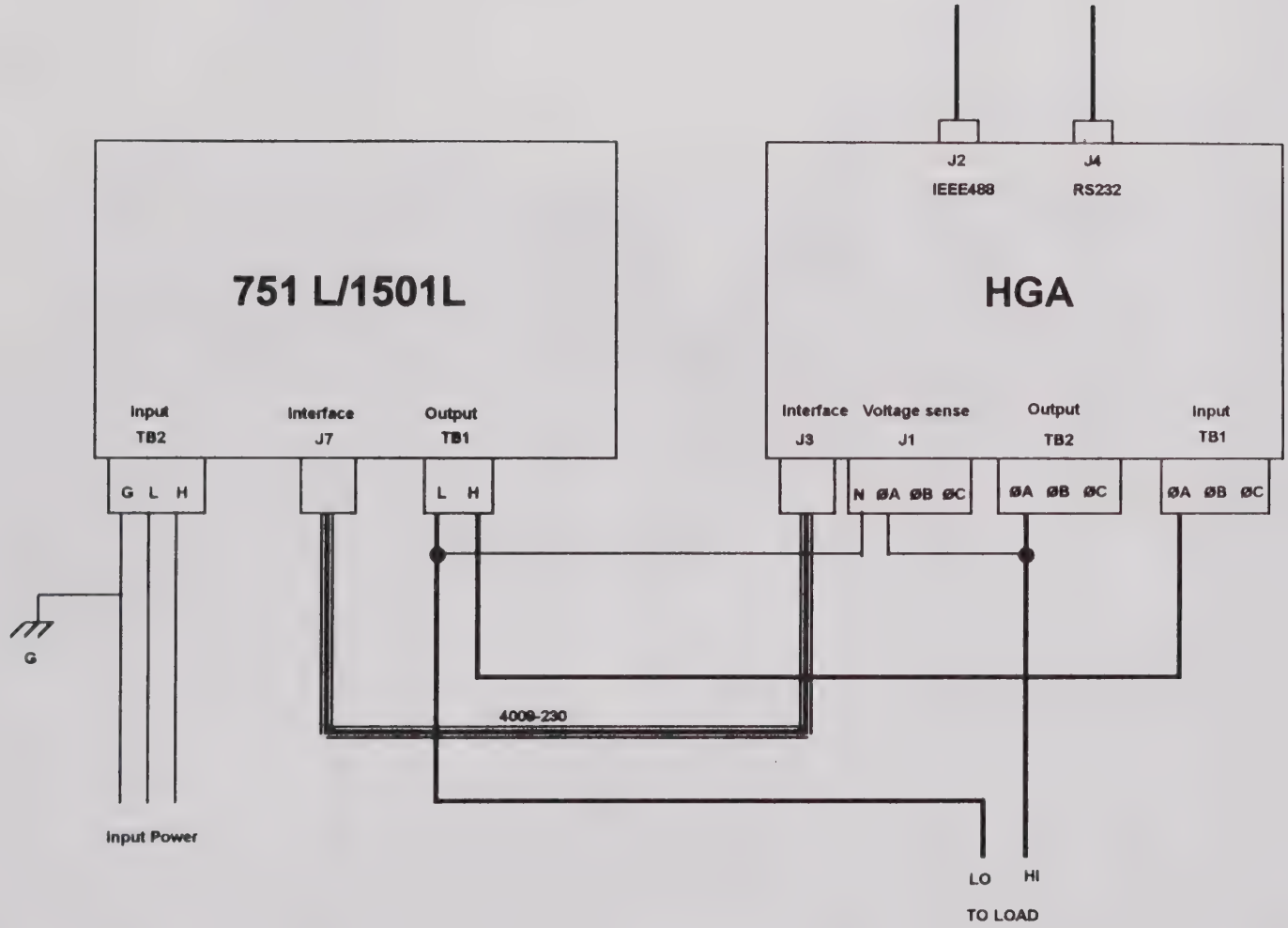


FIGURE 2-3-1
SYSTEM INTERCONNECT
751L/1501L

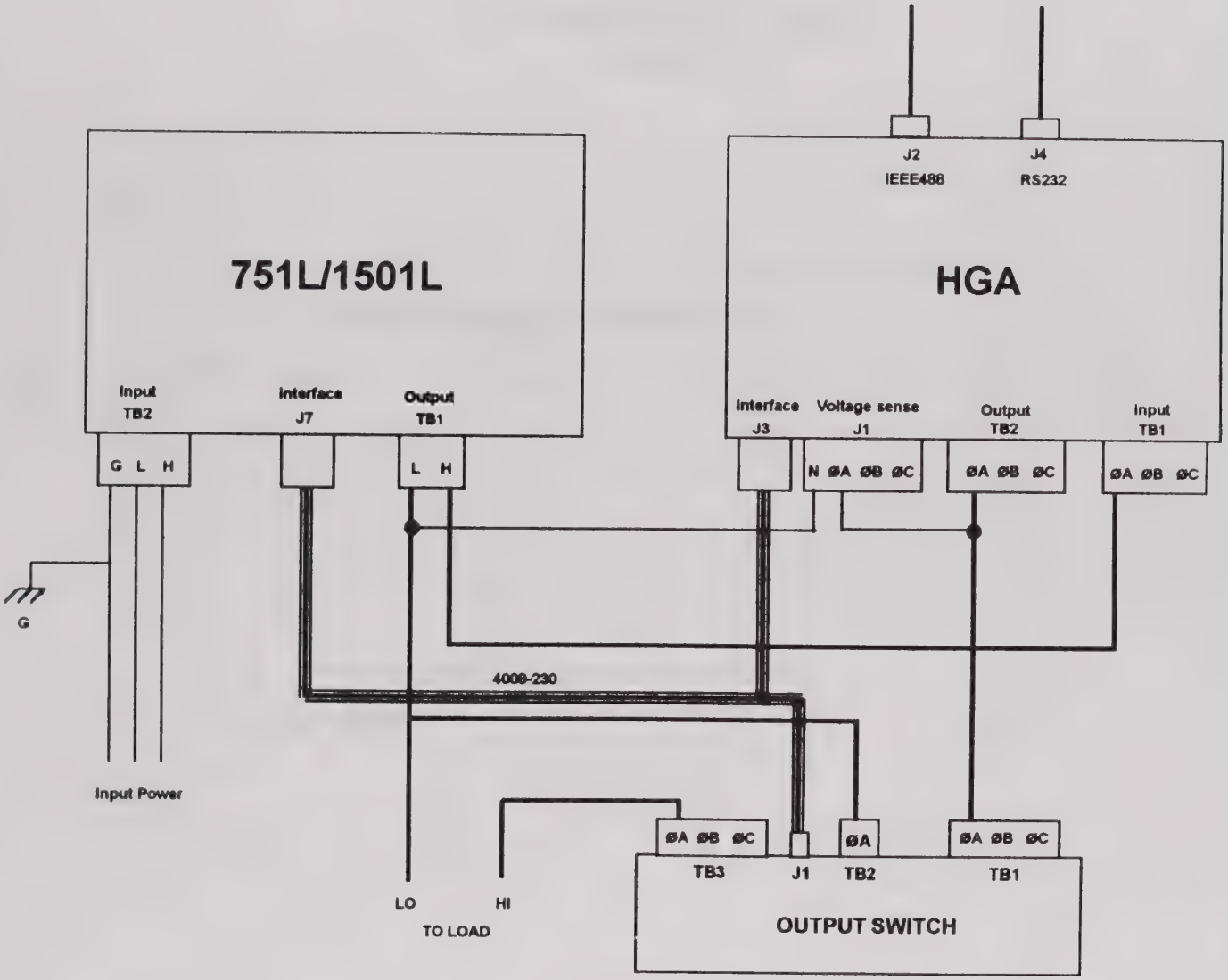


FIGURE 2-3-2
SYSTEM INTERCONNECT
751L/1501L with Output switch

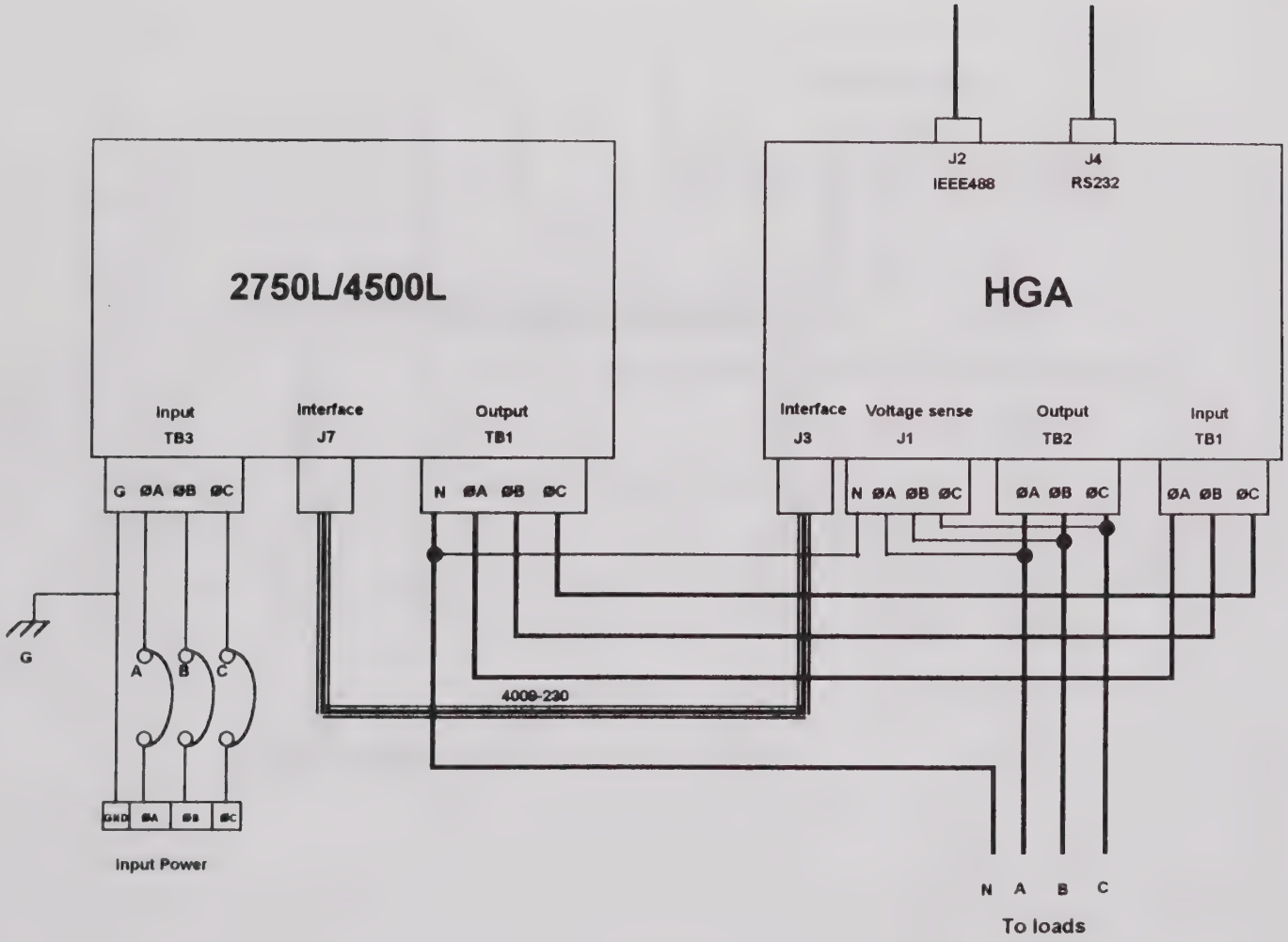


FIGURE 2-3-3
SYSTEM INTERCONNECT
2750L/4500L

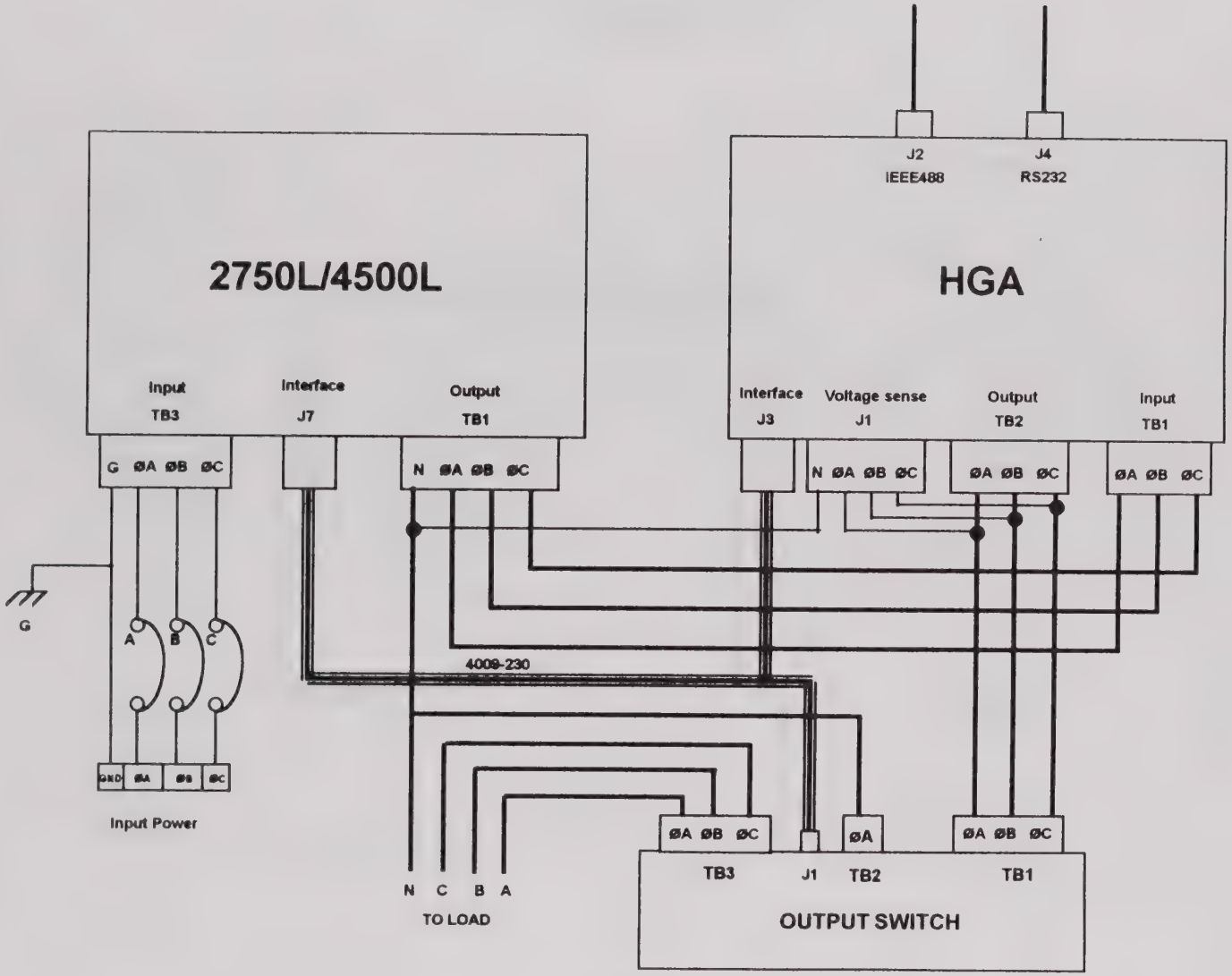


FIGURE 2-3-4
SYSTEM INTERCONNECT
2750L/4500L with Output switch

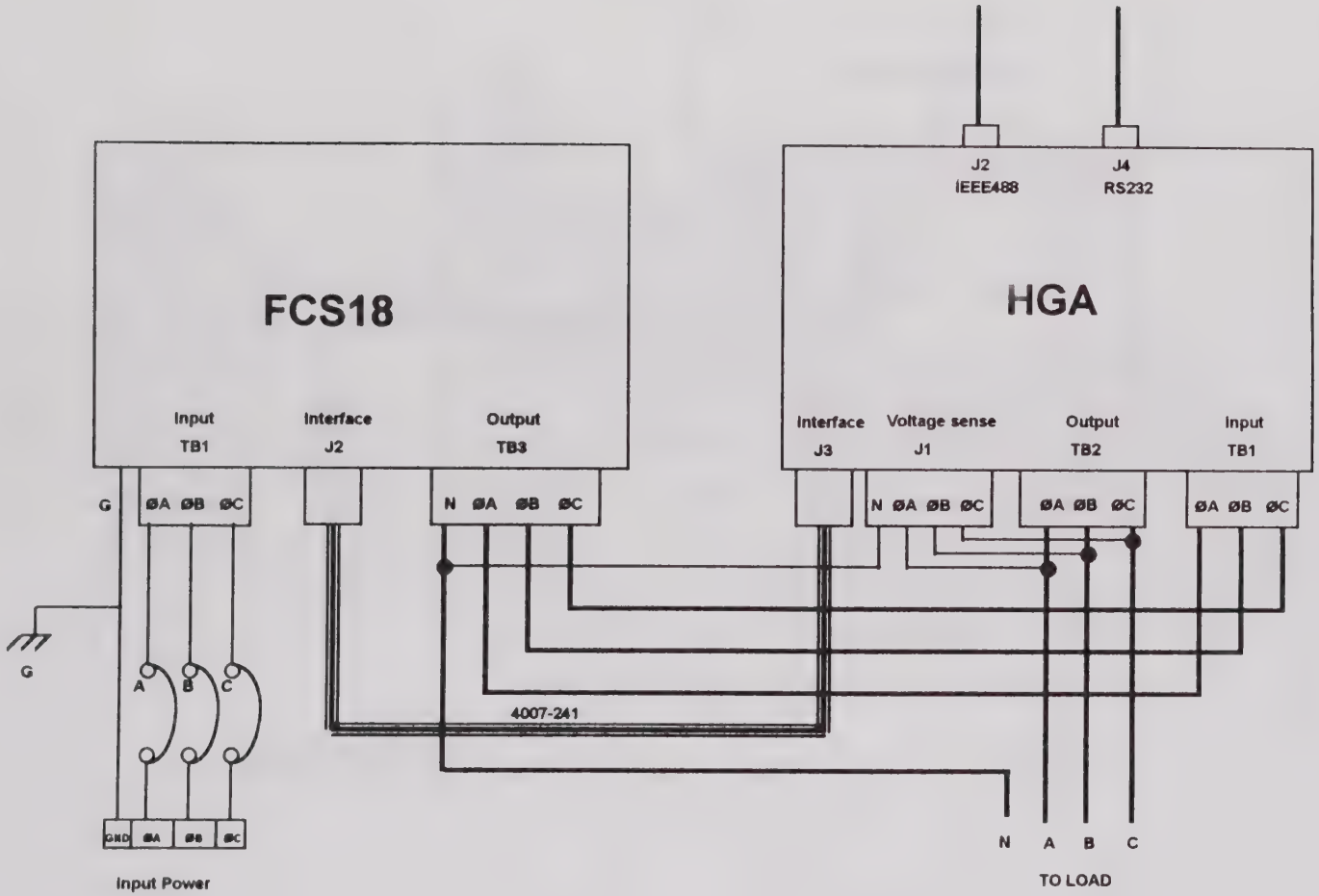


FIGURE 2-3-5
SYSTEM INTERCONNECT
FCS18

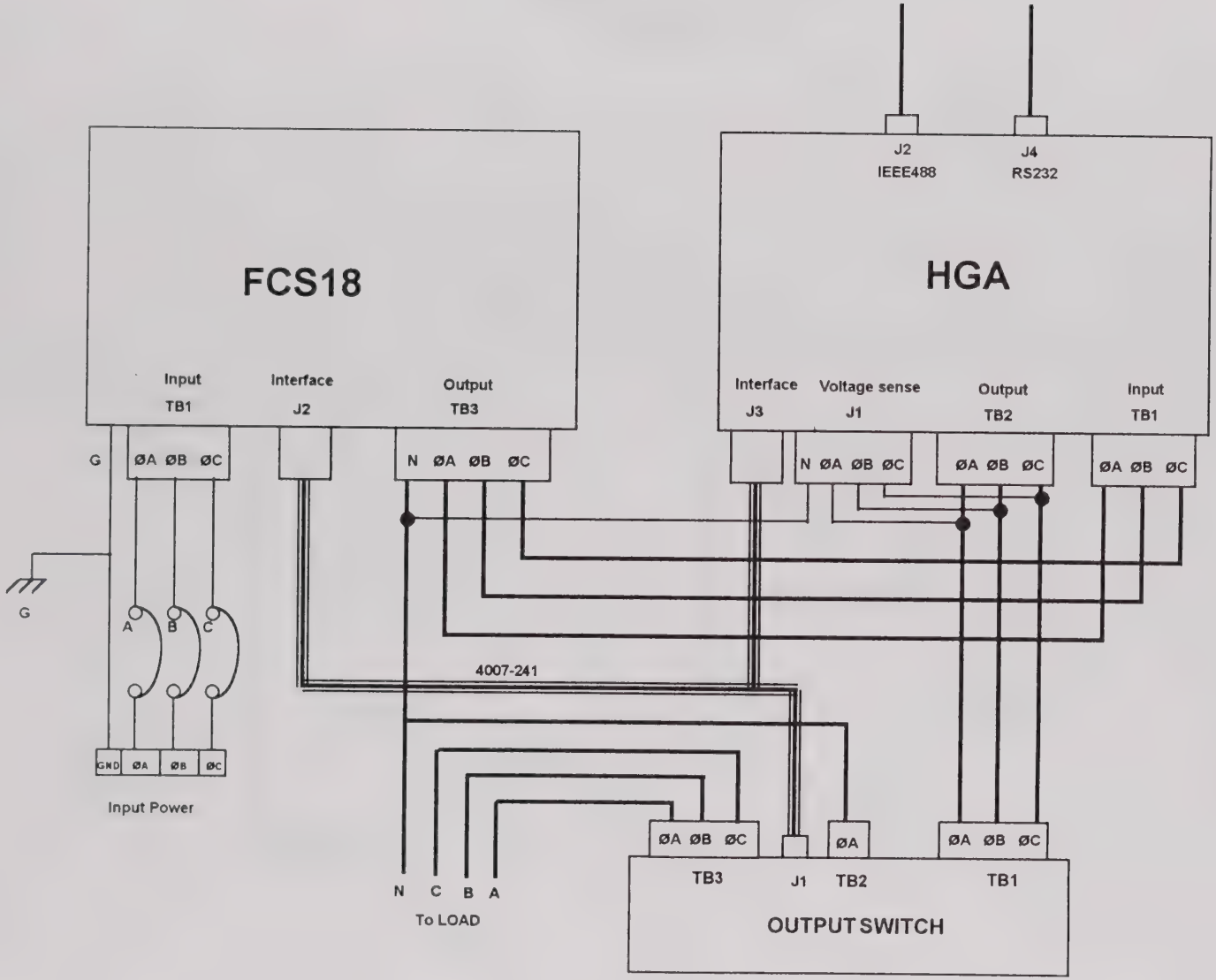


FIGURE 2-3-6
SYSTEM INTERCONNECT
FCS18 with Output switch

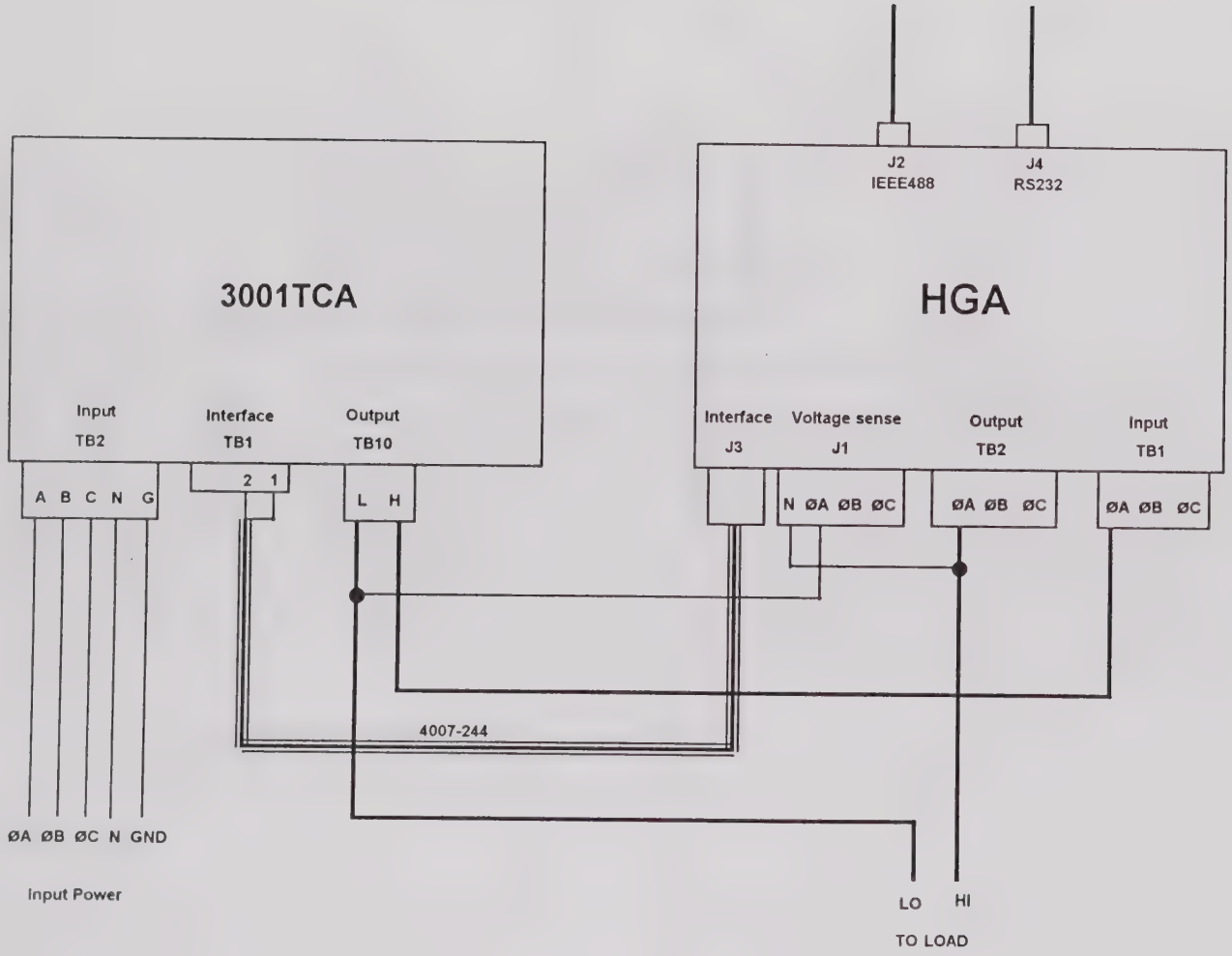


FIGURE 2-3-7
SYSTEM INTERCONNECT
3001TCA single phase

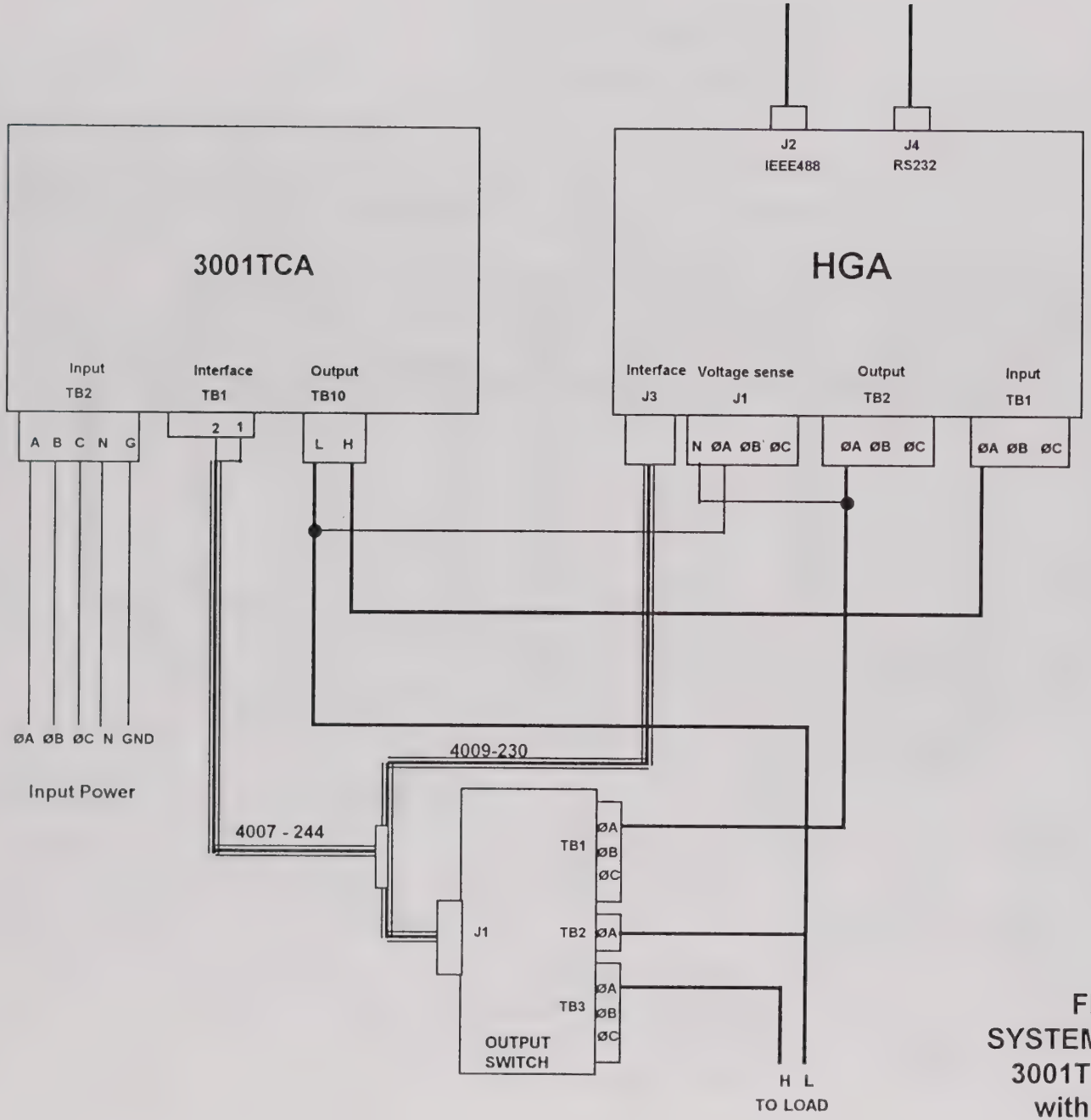


FIGURE 2-3-8
SYSTEM INTERCONNECT
3001TCA single phase
with Output switch

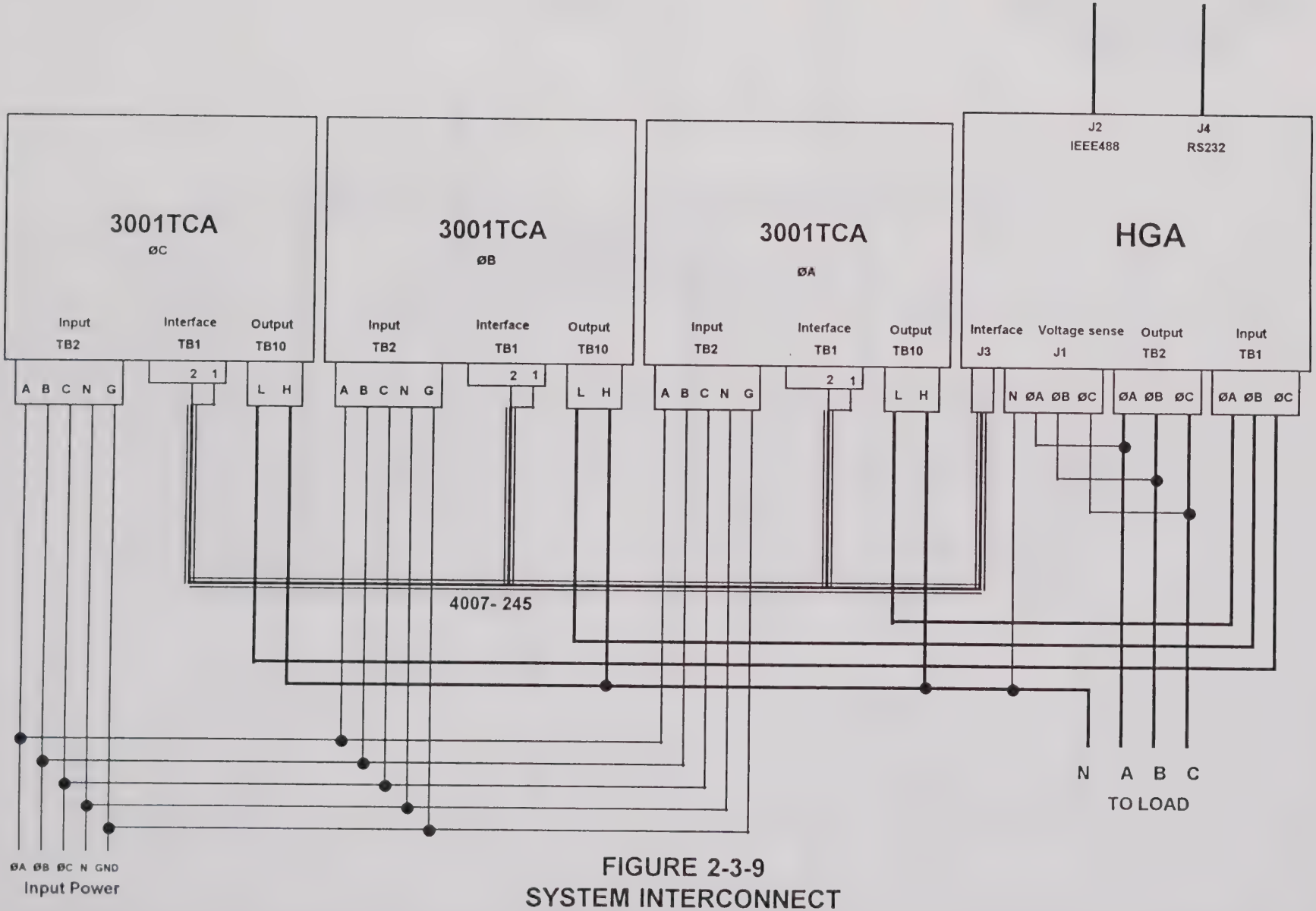


FIGURE 2-3-9
SYSTEM INTERCONNECT
3001TCA three phases

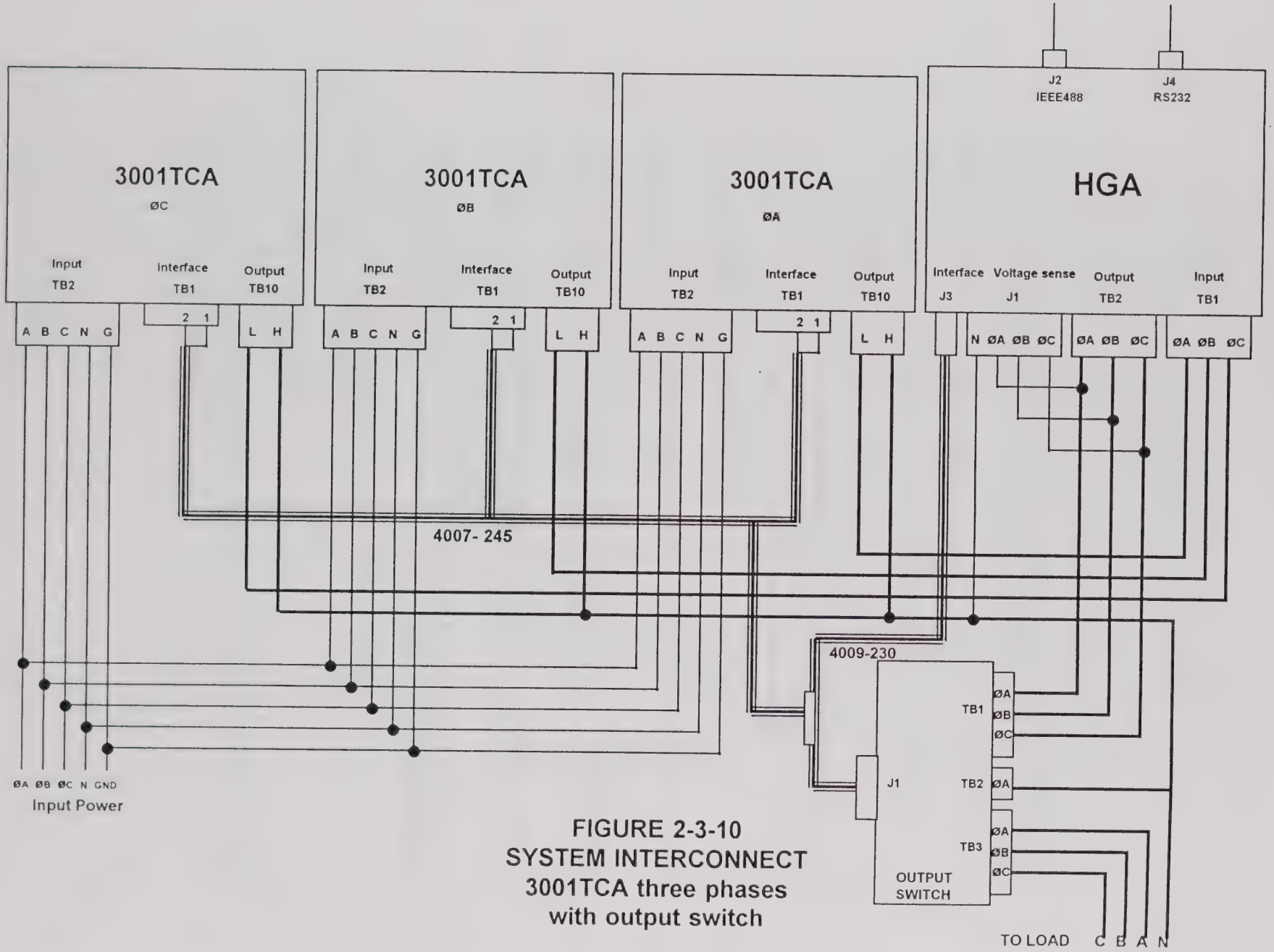


FIGURE 2-3-10
SYSTEM INTERCONNECT
3001TCA three phases
with output switch

SIGNAL	IBM PC DB-25 FEMALE	HGA DP9 FEMALE
RXD	2	2
TXD	3	3
DTR	5	4
RTS	6,8	7
GND	7	5
CTS	20	8

TABLE 2-1

SIGNAL	IBM PC DB-9 FEMALE	HGA DP9
RXD	3	2
TXD	2	3
DTR	8	4
RTS	6,1	7
GND	5	5
CTS	4	8

TABLE 2-2

2.3.6 SYSTEM INTERFACE

J3 is the System Interface connector. Table 2-3 identifies the pins of the System Interface connector.

TABLE 2-3

SYSTEM INTERFACE CONNECTOR (J3)

J3-1 ANALOG COMMON: This is the common for all analog signals on the connector.

J3-2 MR B: This is the input signal to the phase B amplifier from the internal oscillator drive signal. Make no connection to this pin except for troubleshooting.

J3-3 ANALOG COMMON: See J3-1.

J3-4 CS B: Current sum for the phase B output. Make no connections to the pin.

J3-5 CT COMMON:

J3-6 OS B: This is the output from the internal phase B oscillator. Use this pin as an input if an oscillator is not installed. A 5.0 Vrms signal will generate a full- scale output voltage.

J3-7 ANALOG COMMON: See J3-1.

J3-8 CL B: A DC level from the oscillator used to set the current limit for phase B. Make no connection to the pin.

J3-9 External modulation input. A 10 Vrms signal input will amplitude modulate the output 10% of the programmed output voltage. Use J3-1 for common.

J3-10 $\overline{\text{OVR TEMP}}$: A logic low output to indicate an overtemperature condition. Make no connection to the pin.

J3-11 $\overline{\text{CNF}}$: Output relay control indication. This is an output logic line that indicates the state of the output relay. A logic low indicates the output relay is open. Make no connection to the pin.

J3-12 FLT C: Make no connections.

J3-13 FLT A: Make no connections.

J3-14 F STB LO: Function Sync Low signal. This is the emitter lead of an optically isolated NPN transistor. The internal power controller turns this transistor on to indicate a change of programmed values.

J3-15 EX SYNC LO: External Sync Low signal. This is the ground return for the TTL external sync input. It connects to the cathode of an LED at the input of an optocoupler. Refer to J3-32.

J3-16 Solid State control of phase B. Make no connection.

J3-17 Single phase and three phase control. No connection.

J3-18 No connection.

J3-19 MR C: This is the input signal to the phase C amplifier from the internal oscillator drive signal. Do not make any connection to this pin except for troubleshooting.

J3-20 MR A: This is the input signal to the phase A amplifier from the internal oscillator drive signal. Do not make any connection to this pin except for troubleshooting.

J3-21 CS C: Current sum for the phase C output. Make no connection to this pin. Not used for standard configuration.

J3-22 CS A: Current sum for the phase A output. Make no connection to this pin. Not used for standard configuration.

J3-23 OS C: This is the output from the internal phase C oscillator reference. Make no connection except for Troubleshooting.

J3-24 OS A: This is the output from the internal phase A oscillator reference. Make no connection except for Troubleshooting.

J3-25 CL C: A DC level from the oscillator used to set the current limit for phase C. Make no connection to the pin.

J3-26 CL A: A DC level from the oscillator used to set the current limit for phase A. Make no connection to the pin.

J3-27 D COM: Digital common.

J3-28 $\overline{\text{RNG HI}}$: A logic output from the internal oscillator to control the range relays. A logic low on this pin indicates the high voltage range. If the power system is used without an oscillator, this pin is a logic input.

J3-29 Make no connection.

J3-30 FLT B: Make no connection.

J3-31 F STB HI: Function Sync High signal. This is the collector lead of an optically isolated NON transistor. The internal power controller turns this transistor on to indicate a change of programmed values. This output will sink more than 2 milliamps to a TTL low logic output level (< .4 volts). The output is an open, collector optocoupler output. A pullup resistor to a + VDC must be connected to J3, pin 31. J3, pin 14, is the common output. Refer to Figure 2-4.

J3-32 EX SYNC HI: External Sync HI signal. This is an input that can be used to synchronize the outputs of the AC Power System. This input requires a logic high level of at least +4.5 VDC at 5 Ma. The input should have a duty cycle 50 ±30%. J3-15 is the common input. The External Sync input is optically isolated. It must also be enabled from the SNC screen.

J3-33 Solid state control for phase A, make no connection.

J3-34 Solid state control for phase C, make no connection.

J3-36 Remove shutdown. Control this pin to digital ground. J3-27 will cause the output voltage to go to zero voltage.

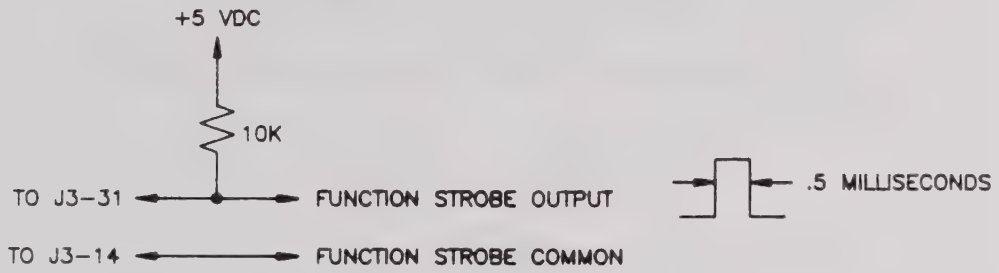


Figure 2-4

FUNCTION SYNC CONNECTIONS

2.4 FUNCTION TEST

Refer to Figure 2-5 for the test setup.

Perform the following test sequence.

1. Apply Input power to both the HGA and the power source. Refer to Figure 2-3 for proper connections between the HGA and the power source.

2. Verify that the power-on lamps are lit for both the HGA and the Power source.

3. From the front panel program the output voltage to full scale volts. Use the Voltage key and the left or right arrow with the knob to reach the program value. Verify the output voltage is about full scale volts.

4. Skip step 5 and 6 if the power source is not equipped with a voltage range change.

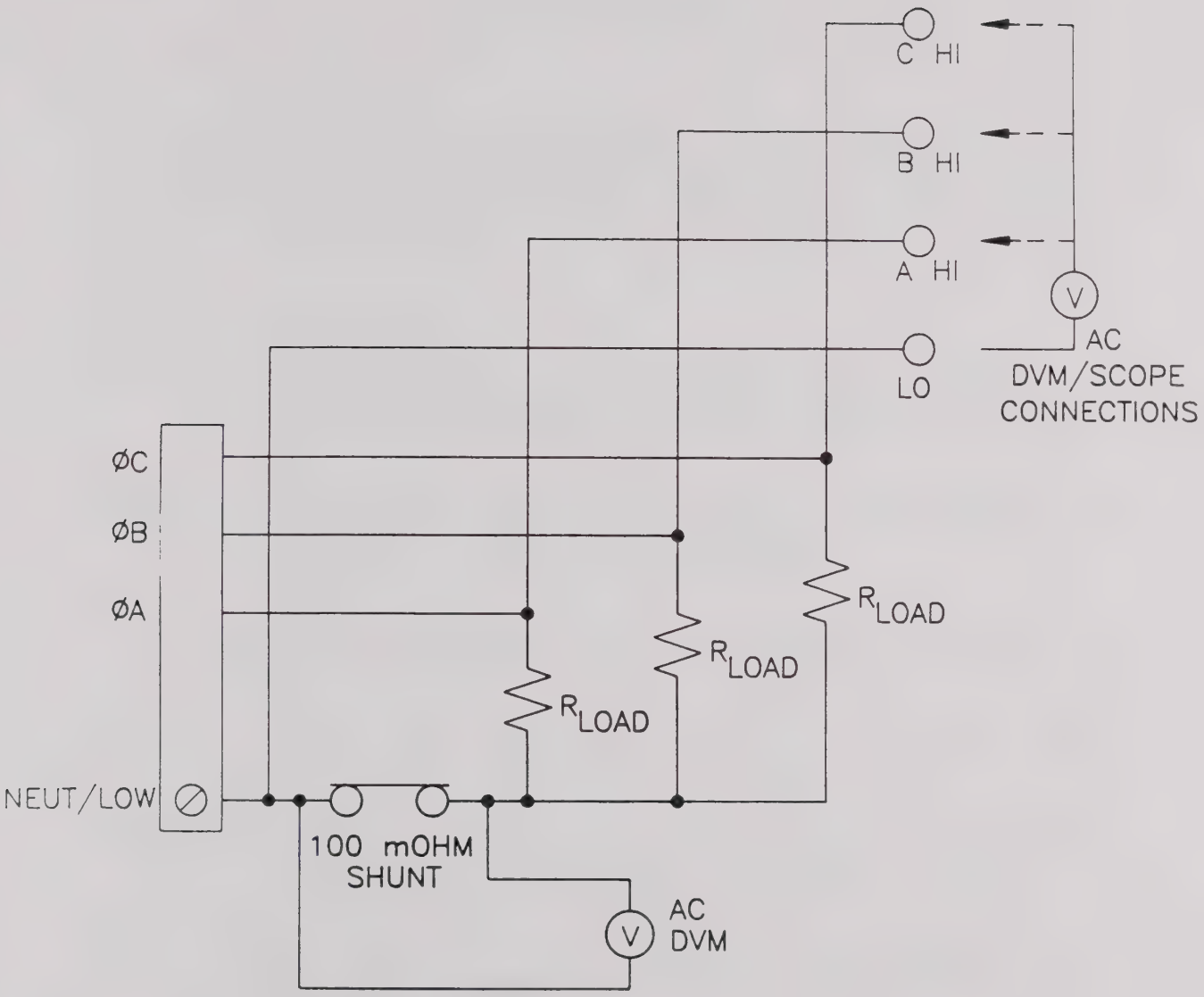
5. From the front panel keypad, select UTILITY key and rotate the knob to select SETUP. Press the right arrow twice and rotate the knob to select the High voltage. Notice the power source high range LED is lit.

6. From the front panel program the output voltage to full scale volts at the high voltage range. Use the voltage key and the left or right arrow with the knob to reach the program value. Verify the output voltage is at full scale volts.

7. Observe each of the outputs with oscilloscope or distortion analyzer. The output should be clean sine wave with less the 1% distortion.

8. Apply full scale voltage to each phase for a three phase system or on phase A only for a single-phase system. Apply a full load and verify that the output voltage remains within 0.5% of full scale voltage at the no load condition.

9. Program the current limit to 80% of the full scale current and notice the output fault to 0 volts.



RLOAD IS THE RESISTIVE LOAD VALUE PER PHASE TO PRODUCE A FULL LOAD CURRENT. REFER TO AC SOURCE MANUAL FOR THE FULL LOAD CURRENT.

FIGURE 2–5
POWER SYSTEM AC POWER OUTPUT FUNCTION SETUP

SECTION 3

LOCAL CONTROL

3.0 GENERAL

The front panel consists of a 2 line LCD with a backlit display, 8 function keys, 2 keys for curser control, rotary encoder and a remote LED. For 3Ø models, all phases are programmed to the slected values. Measured parameters are performed for all three phases. The rotary control allows individual phase measurements to be selected. See Figure 3-1 for front panel layout.

3.1 KEY DESCRIPTIONS:

SET — This key is used to allow stacking of programmable parameters. These parameters are Voltage, Frequency and Current. The entered values are not executed until the EXECUTE key is activated.

MEASURE — This key is used to activate the measured parameter. These parameters are Voltage, Frequency, Current and Power. The measurement is activated when the EXECUTE key is activated after a parameter selection.

VOLTAGE — This key is used to program the output voltage or measure the sensed voltage. The MEASURE key defines its function. All three phases are measured. The knob is used to view phase B and Phase C measurement.

FREQ — This key is used to program the output frequency or measure the sensed frequency. The MEASURE key defines its function.

CURRENT — This key is used to program the current limit or measure the rms load current. The MEASURE key defines its function. All three phases are measured. The knob is used to view phase B and Phase C measurement.

POWER — This key is used to measure the rms power if preceded with the MEASURE key. All three phases are measured. The knob is used to view phase B and Phase C measurement.

UTILITY — This Utility key will access the control of LCD View angle, GPIB listen address, RS232 configuration and the setup for voltage range and single or three phase configuration. The left and right arrow key pads and the knob are used to establish the selection.

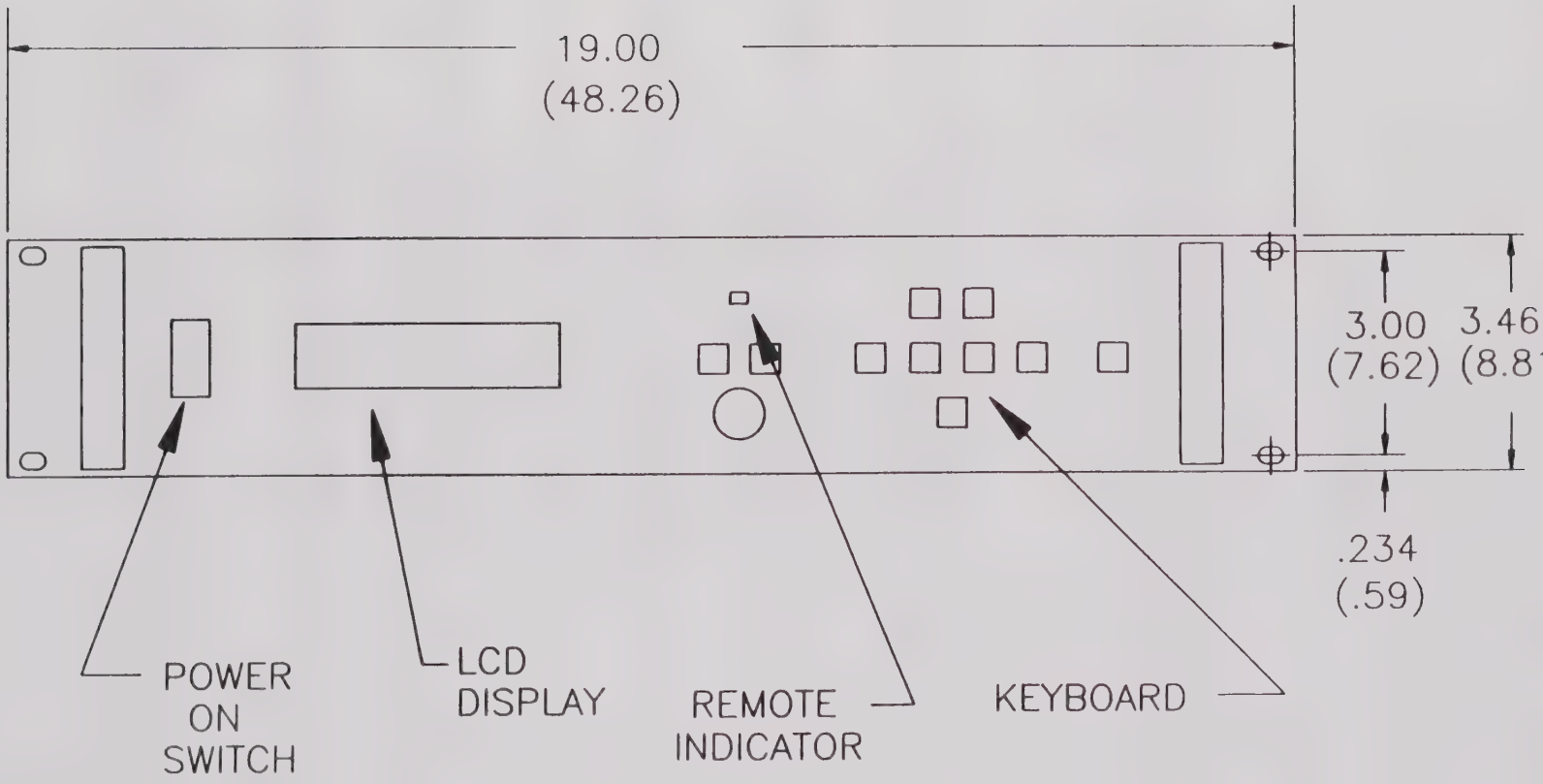

19.00
(48.26)
3.00
(7.62)
3.468
(8.81
.234
(.59)
POWER
ON
SWITCH
LCD
DISPLAY
REMOTE
INDICATOR
KEYBOARD

FIGURE 3-1

3.2 STACKED PROGRAMMING:

The **SET** key allows stacking of the programmable parameters before execution. After power is on press the SET key. The following message will appear on the screen:

Set
Voltage

To program the output voltage press the VOLTAGE key. The following message will appear on the screen as follows:

Set
Volt = 0.0 V

To set the desired output value rotate the knob clockwise to increase the value and counterclockwise to decrease the value. To increase or decrease the incremental size of the steps use the left arrow or the right arrow respectively. The output voltage does not change at this point.

To program the output frequency press the FREQ key after the SET key. The following message will appear on the screen:

Set
Freq = 50.00 Hz

To set the desired frequency use the knob and the left and right arrows as the voltage programming.

To program the current limit value press the CURRENT key after the SET key. The following message will appear on the screen

Set
Curr = 12.1 A

To change the current limit setting use the knob and the left and right arrows.

To execute all the stacked parameters, press the EXECUTE key. All output parameters will change to the program setting values.

3.3 IMMEDIATE PROGRAMMING

Immediate programming is accomplished by selecting the desired function key and dialing the program value using the knob and the left and right arrow keys.

To program the output voltage select the VOLTAGE key. The following message will appear on the display:

```
Immediate
Volt  =     100.0  V
```

To change the output voltage use the right and left arrow to control the size of the steps and rotate the knob to the right or to the left to increase or decrease the output voltage. The output voltage will change immediately with the change in the displayed value.

To program the output frequency select the FREQ key. The following message will appear on the screen.

```
Immediate
Freq  =   60.00  Hz
```

To change the output frequency use the knob and the right and left arrow. The output frequency will change immediately with the change in the displayed value.

To program the current limit select the CURRENT key. The following message will appear on the screen.

```
Immediate
Curr  =   11.2  A
```

To change the current limit setting use the knob and the left and right arrows.

3.4 MEASUREMENT

Measurement are accomplished by selecting the MEASURE key followed by one of the measurement functions key and the EXECUTE key. When the measurement are completed use the knob to view the measurement for each phase.

Press the MEASURE key. The following message will appear on the screen.

```
Measure
Volt  = OFF
```

To measure the voltage, press the VOLTAGE key. The following message will appear on the screen.

```
Measure
Volt  = ON
```

To start the measurement press the EXECUTE key. The following message will appear on the screen

Measuring . . .

The message will remain until the measurements are completed and the display will show phase A measurement in the following format:

Measured
Volt A = 115.0

To view the measured value for phase B and phase C, rotate the knob clockwise once or twice.

To measure the frequency, press the MEASURE key followed by the FREQ key and the following message will appear on the screen.

Measure
Freq = ON

To start the measurement press the EXECUTE key. The message Measuring... will appear on the screen until the measurement is completed. The display will show the measured frequency value as follows:

Measured
Freq = 50.0 Hz

To measure current, press the MEASURE key followed by the CURRENT key. The following message will appear on the screen.

Measure
Curr = ON

To start the measurement press the EXECUTE key. The message Measuring... will appear on the screen until the measurement are completed. The display will show the measured current value as follows:

Measured
Curr A = 11.5 A

To view the measured value for phase B and phase C current, rotate the knob clockwise.

To measure power, press the MEASURE key followed by the POWER key. The following message will appear on the screen.

```
Measure
Power  = ON
```

To start the measurement, press the EXECUTE key. The message Measuring ... will appear on the screen until the measurement are completed. The display will view the measured value as follows:

```
Measured
Power  A  =   1.20 Kw
```

To view phase B and phase C measurements, rotate the knob clockwise.

3.5 UTILITY

The utility key will control the following functions:

1.	LCD viewing angle control	LCD
2.	GPIB listen address	GPIB
3.	Serial communication configuration	RS232
4.	Voltage Range and single or three-phase	SETUP
	Range change	SETUP: RANGE
	Singe or three-phase configuration	SETUP: Mode

To select the utility, press the UTILITY key. The following message will appear on the display.

```
Utility
LCD
```

To select any of the functions listed above, rotate the knob clockwise until the desired function appears on the screen.

3.5.1 LCD

This function will control the view angle of the LCD display. Press the right arrow. The display will appear in the following format:

```
Util:LCD
Cont  =      5.0
```

The value that appears on the screen is a value between 0 and 10. Changing this value will affect the viewing angle. To change the value use the left or right arrow and the knob. Note a value less than 4 will cause the display characters to disappear from the screen.

3.5.2 GPIB LISTEN ADDRESS

If the display does not show the main utility menu, press the left arrow to go to the main menu. Rotate the knob until the display shows as follows:

Utility
GPIB

Press the right arrow. The display will show the following:

Util:GPIB
Address

Press the right arrow one more time to display the GPIB listen address

Util:GPIB
Adr = 16

Rotate the knob to change the listen address to the desired address.

Press the left arrow once and rotate the knob clockwise to select the listen only mode and the display will show as follows:

Util:GPIB
ListenOnly

3.5.3 RS232 CONFIGURATION

If the display does not show the main utility selection, press the left arrow. Rotate the knob until the following menu is shown:

Utility
RS232

Press the right arrow to view the various RS232 parameter selections. Rotate the knob to select the desired parameter. The display will show the following screen each time the knob advances.

Util:RS232
Baud Rate

Util:RS232
Parity Bit

Util:RS232
Bits

Util:RS232
Handshake

Pressing the right arrow for any one of the above screens will display their parameters as follows:

Util:RS232
Baud = 9600

Rotate the knob to select 1200, 2400 or 9600 baud.

Util:RS232
Parity = None

Rotate the knob to select between None, Odd or Even.

Util:RS232
Bits = 8D1S

Rotate the knob to select between 8D1S, 8D2S, 7D1S or 7D2S. Where the D is the number of bits and S number of stop bits. **Selecting 7 data bits could cause problems. Some of the data require 8 data bits.**

Util:RS232
HandShk = HW

Rotate the knob to select HW or SW. **HandShake must always be HW.**

3.5.4 SETUPS

If the display does not show the main utility selection, press the left arrow. Rotate the knob until the following menu is shown:

```
Utility
SETUP
```

Use the right arrow to enter the SETUP menu. Rotating the knob will display the following selection:

```
Util:SETUP
Range
```

```
Util:SETUP
Mode
```

Press the right arrow key when any of the above is visible to select one of its parameters.

```
Util:SETUP
Range  =  Low
```

Rotate the knob to select Low or High Voltage range. This selection is only allowed if the option is enabled. This option is power source dependent.

```
Util:SETUP
Mode  =  1  Phase
```

Rotate the knob to select 1-Phase or 3-Phase configuration. This selection is only allowed if the option is enabled. This option is power source dependent.

SECTION 4

REMOTE PROGRAMMING

4.0 GENERAL

Remote programming can be achieved from the GPIB or from the RS232. The Listen Address must be set properly from the Local Control. Refer to Section 3.5.2 under Utility for Listen Address setting.

RS232 setup must be set for the proper baud rate and data format. Data should be set to 8 bits to ensure proper down load of waveforms. Refer to Section 3.5.3 for RS232 setup. Refer to Section 8.6.1 for RS232 and GPIB setup examples. <sp> will be used throughout the programming examples. This symbol means a space is required.

4.1 STEADY STATE PROGRAMMING

For AC sources with Output Relay, closing the relay is required with the following command:

OUTPUT <sp> ON.

4.1.1 VOLTAGE PROGRAMMING

The output voltage of the power source is controlled with the voltage command. To set the output Voltage for phase A to 115 volt, use the following command:

VOLT1<sp>115 or
VOLT<sp> 115

To program all three outputs to the same voltage simultaneously, the coupling is set to all with the following command.

COUP<sp>ALL

To find the maximum output voltage the HGA will accept, use the following command.

VOLT1?<sp>MAX

To change the output voltage range to the high range use the following command:

VOLT1:RANG<sp>HIGH

4.1.2 FREQUENCY PROGRAMMING

The output frequency of the HGA is controlled by the FREQ command. To change the output frequency to 60 Hz use the following command.

FREQ<sp>60

To find the maximum frequency program value, query the HGA with the following command

FREQ?<sp>MAX

To find the minimum frequency program value, query the HGA with the following command.

FREQ?<sp>MIN

4.1.3 CURRENT LIMIT PROGRAMMING

The Current Limit for the power source is controlled by the CURR command. To change the current limit of phase A to 5 amps use the following command:

CURR1<sp> 5 or
CURR<sp> 5

To find the maximum current the power source could provide, use the following command.

CURR?<sp>MAX

To change the current for all three phases simultaneously, set the coupling to ALL with the following command:

COUP<sp>ALL

To change the current limit for all three phases to 4 amps use the following command after the coupling is set to all.

CURR<sp>4

To change the current for individual phase, change the coupling to NON with the following command:

COUP<sp>NON

4.1.4 PHASE ANGLE PROGRAMMING

The Output Phase Angle of the HGA can be controlled with the PHASE command. To change the phase angle of phase B to 90°, use the following command:

PHAS2<sp>90

4.1.5 WAVEFORM SHAPE

The waveform shape could be a sine wave, a clipped sine wave or one of the 18 waveforms stored in the HGA memory. The clip level is defined by the percentage distortion.

The following command will program the output waveform to a sine wave with a clip level that produces a 5% distortion.

FUNC:CSD<sp>5

To program the output to sine wave use the following command:

FUNC<sp>SIN

The following command will program the output waveform with a waveform that is stored in the HGA memory:

FUNC "WAVE1"

Where WAVE1 is a custom waveform loaded previously.

4.1.6 EXTERNAL SYNCHRONIZATION

The output frequency can be locked to external frequency source in value and phase. The external frequency source must be a TTL level and a frequency within the frequency range of the HGA.

The following command will lock the internal frequency to the external source.

FREQ:MODE<sp>SENS

To change the frequency to internal, use the following command:

FREQ:MODE<SP>FIX

4.1.7 VOLTAGE SLEW

The interface has the ability to control the voltage slew rate of the HGA. This could be used to generate a voltage ramp. The voltage slew rate is set for maximum at the power up. To change the slew rate of phase A voltage to 100 volts per second, the following command is used.

VOLT1:SLEW<sp>100

To set the slew rate to a maximum the following command is used:

VOLT1:SLEW<sp>MAX

The slew rate applies to all voltage program changes in FIXed, STEP or PULSe subsystems.

4.1.8 FREQUENCY SLEW

The interface has the ability to control the frequency slew rate of the HGA. This could be used to generate frequency ramps. The frequency slew rate is set for maximum at the power up. To change the frequency slew rate to 10 Hz per second, the following command is used.

FREQ:SLEW<sp>10

To set the frequency slew rate to a maximum the following command is used:

FREQ:SLEW<sp>MAX

The slew rate applies to all frequency program changes in FIXed, STEP or PULSe subsystem.

4.2 TRANSIENT PROGRAMMING

The interface has three modes to generate output transient:

Fixed:	Does not respond to the trigger command.
Step:	A single triggered output change from the Fixed value to the Step value.
Pulse:	A transient change will return to its original fixed value after some time period.
List:	A sequence of amplitude data, each with an associated dwell time or paced by triggers.

The output transients are useful to generate a complex of output changes with precise timing. The transient could be triggered with an internal or external command and at a specific phase angle of the waveform.

The following parameters can be used in transient definitions.

Voltage, Frequency, Current Limit, Phase Angle, Voltage slew and Frequency slew.

4.2.1 STEP PROGRAMMING

The following example will set the output voltage for phase A to 115 volts and the start angle of 90°.

If you are not sure of the states of the transient parameter, use the reset command to initialize the system to the initial condition.

*RST

Close the output relay if the power source is equipped with an output relay.

OUTPUT < sp > ON

Set the voltage mode to STEP.

VOLT1:MODE < sp > STEP

Set the voltage trigger level to 115 Volts.

VOLT1:TRIG < sp > 115

Set the trigger arm source to immediate

TRIG:ARM:SOUR < sp > IMM

Set the trigger source to internal, the transient will start at specific phase angle.

TRIG:TRIG:SOUR < sp > INT

Set the triggered phase angle to 90°.

TRIG:TRIG:PHAS < sp > 90°

To initiate the transient with the following command:

```
TRIG:INIT
```

To step the output voltage from 0 volts to 115 voltage with a slew rate of 1000 volts per second and the sequence initiated with the trigger command, use the following sequence:

```
VOLT1:MODE<sp>STEP
VOLT1:TRIG<sp>115
VOLT1:SLEW:MODE<sp>STEP
VOLT1:SLEW:TRIG<sp>1000
TRIG:TRIG:SOUR<sp>IMM      (Default setting)
TRIG:INIT
```

Frequency steps can be achieved in the same way as the voltage steps example above. **No slew rate commands are associated with the phase and current step.**

4.2.2 PULSE PROGRAMMING

The following example will show how to step the output voltage for all three phases from 115 volts to 135 volts for one cycle and return to 115 volts.

Set the output voltage and frequency to 115 volts and 50 Hz.

```
COUP<sp>ALL
FREQ<sp>50
VOLT<sp>115
```

Set the voltage mode to pulse and the voltage trigger value to 135.

```
VOLT:MODE<sp>PULSe
VOLT:TRIG<sp>135
```

Set the pulse width to 20 msec.

```
PULS:PER<sp>0.04
```

NOTE: Pulse width is set for 50% duty cycle at power up.

Initiate the internal trigger with the following command:

```
TRIG:TRIG:SOUR<sp>IMM
TRIG:INIT
```

4.2.3 LIST PROGRAMMING

The list programming mode allows the generation of complex sequences of output changes with rapid precise timing control by the dwell delay associated with each step or controlled by the trigger received.

The following example is given for a simple list of voltage and frequency. This example will set both voltages and frequency for 115 volts and 60 Hz for 20 msec. Voltage and frequency will change simultaneously to 125 volts and 55 Hz for 20 msec. Then both the voltages and frequency will return to 115 volts and 60 Hz.

Set the mode to LIST for both voltage and frequency as follows:

```
VOLT:MODE LIST
FREQ:MODE LIST
```

Set the voltage and frequency list data points as follows:

```
LIST:VOLT<sp>115,125,115
LIST:FREQ<sp> 60,55,60
```

Set the dwell time between the above data points. If the dwell time is the same between these data points, one data point could describe them all.

```
LIST:DWELl 0.020.
```

If dwell time is different between data points, the dwell list must have the same number of data points.

```
LIST:DWELl<sp>0.020,0.002,0.020.
```

The shortest dwell time must be 0.002 second in 0.001 second increments to a maximum of 300 seconds per data point.

Initiate the above program with the following command:

```
TRIG:INIT
```

4.3 TRIGGER CONTROL

The HGA Trigger subsystem can be Armed Immediate or wait for a bus Group Execute Trigger command as follows:

TRIG:ARM:SOUR<sp>IMM or
TRIG:ARM:SOUR<sp>BUS

The trigger initiation could be in continuous mode or single trigger depending on the continuous status as follows:

TRIG:INIT:CONT<sp>ON. or
TRIG:INIT:CONT<sp>OFF

The HGA Trigger source could be Immediate or Internal. The internal trigger is synchronized by the phase angle relative to phase A. The trigger phase should be set to the desired phase angle.

TRIG:TRIG:SOUR<sp>IMMediate no internal condition is required
or TRIG:TRIG:SOUR<sp>INTernal the trigger phase angle must be specified or the trigger subsystem will use the default trigger phase angle. To specify the phase angle the following command must be used.

TRIG:TRIG:PHAS<sp>90 will set the phase angle for 90°

The trigger could be delayed by certain amounts of time from the trigger command with the following command:

TRIG:TRIG:DELay<sp>0.02 20 msec delay.

The following command will activate the trigger:

TRIG:INITiate

To abort the transient at any time the following command is used:

TRIG:ABORT

4.4 MEASUREMENT

The HGA has the capability to return the rms voltage, rms current, rms power, peak current, harmonic current, harmonic voltage, phase angle and frequency measurement. The responses to all measurements are in NR2 format.

Current measurement has 4 ranges for the standard configuration. These ranges are 2 amps, 4 amps, 8 amps and 16 amps. The measurement subsystem auto ranges between the 2 amp and the 4 amp ranges. It also auto ranges between the 8 amp and the 16 amp ranges. User must select the proper range for the current measurement for currents less than 4 amps and currents above 4 amps for optimum results. The load must be removed to change range from any value below 4 amps to a value above 4 amps and vice versa. The following command is used to range change the current.

MEAS:RANGE<sp>4 will set the measurement to 4 amps range.

Power measurement, peak current measurement and harmonic current measurement require range selections for accurate results.

4.4.1 RMS VOLTAGE, CURRENT AND POWER MEASUREMENTS

To measure the rms Voltage for phase A, use the following command:

MEAS:VOLT1?

To measure the rms Current for phase B, use the following command:

MEAS:CURR2?

To measure the rms Power for Phase A, use the following command:

MEAS:POW? Note the absence of the channel number designate phase A.

4.4.2 PEAK CURRENT MEASUREMENT

The peak current measurement is activated with the following command:

MEAS:CURR1:AMPL:MAX?

This command will return the peak current value for phase A measurement. After the peak current for this channel is selected, peak current measurement will track the peak value. Subsequent peak current measurement for the same channel will return the highest value.

To measure the peak current for other channels requires resetting the peak current measurement circuit. Peak current measurement reset is also required whenever the user needs to find the peak current value at the time of measurement. The following command is used to reset the peak current measurement and should proceed the peak current measurement.

MEAS:CURR:AMPL:CLEAR

4.4.3 APPARENT POWER, POWER FACTOR AND CREST FACTOR MEASUREMENT

The Measurement subsystem will return Apparent Power, Power factor and Crest factor by measuring the appropriate component and returning the computed values.

The following command will return the apparent power in kVA for phase A.

MEAS:POW1:APP?

The following command will return the power factor between 0 and 1 for phase B

MEAS:POW2:PFACT?

The following command will return the crest factor of load current for phase C.

MEAS:CURR3:CREStfactor?

4.4.4 HARMONIC MEASUREMENTS AND HARMONIC DISTORTION

The Measurement subsystem is able to measure both voltage and current harmonics. The subsystem will measure either a single harmonic or an array of harmonics up to the 49th harmonic. The subsystem will compute the total harmonic distortion up to the 49th harmonic. Current range should be selected prior to measurement to obtain accurate results.

The following command will measure the 3rd harmonic of phase A current for a fundamental frequency of 50 Hz.

MEAS:CURR1:HARM?<sp>50,3

The following command will measure the array of current harmonics of phase A up to the 39th harmonic for a fundamental frequency of 50 Hz.

MEAS:ARRAY:CURR1:HARM?<sp>50,39

The following command will measure the array of current harmonics of phase A to the 49th harmonic for a fundamental frequency of 50 Hz and will compute and return the Total harmonic distortion as a percentage of the fundamental.

MEAS:CURR1:HARM:THD?<sp>50

Voltage harmonic could be measured in the same fashion as above.

4.5 CALIBRATION

Refer to Section 6, Adjustment and Calibration procedure section in this Manual.

SECTION 5

HGA SCPI COMMAND REFERENCE

5.0 GENERAL

This section provides detailed description of the HGA SCPI Command.

5.1 NOTATION

The following notations are used

- o Command headers are shown in mixed case. The upper case portions indicate the short form of the command. Case is not significant in programming the interface.
- o Items contained within square brackets [ ] are optional.
- o Items separated by a vertical bar indicate alternative.
- o Items within angle brackets < > are parameter abbreviations.

5.1.1 PARAMETER ABBREVIATIONS

NRf Device listening flexible numeric format, which is flexible in accepting optional signs, number of digits before or after an optional decimal point, and optional 10 multiplier.

bool Boolean parameter notation.

CRD character response data

sp space 20 hex

5.1.2 RESPONSE FORMAT ABBREVIATION

NR1 Integer with optional sign.

NR2 Real number with decimal points.

NR3 Real number in exponential notation.

All commands that accept numeric parameters will accept a MINimum or MAXimum instead of the numeric format. Use the query command followed by the MINimum or MAXimum as a parameter to find the range of numeric data the command will accept.

5.2 SYSTEM

SYSTem:VERSion?

The query System Version command returns the SCPI revision number.

Example:
SYST:VERS?

Response:
1991.0

SYSTem:ERRor?

This query command will respond with the generic error number and error string.

Example:
SYST:ERR?

Response:
The following are all possible responses:

0, "No error" response when there are no errors.
-100, "Command error" generic response for syntax error.
-200, "Execution error" response to data errors, string errors, hardware errors and trigger errors.
-300, "Device specific error" system error, memory error and overflow error.
-400, "Query error" The output queue has a problem.

SYSTem:LOCal

This command will set the HGA in local and allow Keypad operation. This command is only active in RS232 operation.

Example:
SYST:LOC

SYSTem:REMote

This command will set the HGA in remote and will lock any keypad operation. This command is only active in RS232 operation.

Example:
SYST:REM

5.3 OUTPUT SUBSYSTEM

OUTPut[:STATe] < sp > ON ¦ OFF

This command will close or open the output relay

Initial
OFF

Example:
OUTP ON
output OFF

OUTPut[:STATe]?

This query command will return the status of the output relay

Example:
OUTP?

Response:
1 ¦ 0

OUTPut:TTLTrg[:STATe] < sp > ON ¦ OFF

This command will enable or disable the output sync

Initial:
OFF

Example:
OUTP:TTLT ON

OUTPut:TTLTrg[:STATe]?

This query command will return the status of the output trigger

Example:
OUTPut:TTLTrg?

Response:
0 ¦ 1

OUTPut:TTLTrg:SOURce < sp > BOT | EOT | LIST

This command will define the source of the output trigger, begin of transient, end of transient and begin of a list.

Initial:
BOT

Example:
OUTP:TTLT:SOUR EOT

OUTPut:TTLTrg:SOURce?

This query command will return the status of the trigger source.

Example:
OUTP:TTLT:SOUR?

Response:
BOT | EOT | LIST

5.4 SOURCE SUBSYSTEM

[SOURce:]MODE < sp > ONEPhase | THReephase

This command will configure the HGA and the power source to a single-phase or three-phase configuration.

Initial:
Depend on the configuration switches in the control board.

Examples:
MODE ONEPHASE
SOURCE:MODE THREEPHASE

[SOURce:]MODE?

This query command will return the status of the mode configuration. The response will be ONE or THR

Examples:
MODE?
SOUR:MODE?

Responses:
ONE | THR

[SOURce:]VRANge <sp> LOW|HIGH

This command will select the High or Low voltage range if the HGA is configured as a dual voltage range.

Initial:
Defined by the INITial:VRANge in the initial subsystem.

Examples:
SOUR:VRAN LOW
vrange LOW
vran LOW

[SOURce:]VRANge?

This query command will return the status of the voltage range. The response will be HIGH or LOW.

Examples:
VRANge?

Responses:
HIGH | LOW

[SOURce:]COUPle <sp> NONE|ALL

This command will allow the voltage and current programming for all three phases simultaneously. At power-up the coupling is set to none.

Initial:
NONE

Examples:
source:couple none
coup ALL

[SOURce:]COUPle?

This query command will return the status of the coupling.

Examples:
SOUR:COUP?

Responses:
ALL ¦ NONE

[SOURce:]FREQuency[:IMMediate] < sp > < NRf >

This command will program the immediate output frequency to a value specified by the NRf. At power up the immediate value is equal to the initial value.

Initial:
Defined by the initial frequency in the initial subsystem.

Examples:
FREQ 60.0
SOUR:FREQ 6e1

[SOURce:]FREQuency[:IMMediate] ?

This query command will return the immediate output frequency value.

Example:
FREQUENCY?
source:freq?

Responses:
< NR2 >

[SOURce:]FREQuency:MODE < sp > FIXed | STEP | PULSe | LIST | SENSe

This command will control the source of the programmed frequency as follows:

FIXed	Frequency is updated upon receiving the immediate value.
STEP	Frequency is updated from the triggered value upon receiving a trigger.
PULSe	Frequency is updated from the triggered value upon receiving a trigger and for a duration defined by the PULSe
LIST	Frequency is updated from the values defined by the LIST upon receiving a trigger command.
SENSe	Frequency will lock to the external Sync frequency.

Initial:
FIXed

Examples:
FREQ:MODE FIX
FREQ:MODE SENS

[SOURce:]FREQuency:MODE?

This query command will return the status of the frequency mode FIX, STEP, PULSe, LIST or SENSe

Example:
FREQ:MODE?

Responses:
FIX | SENS

[SOURce:]FREQuency:TRIGgered < sp > < NRf >

This command sets the triggered frequency value. The output frequency is programmed with the triggered value when the MODE is set for STEP or PULSe and the trigger is initiated.

Initial:
0

Example:
FREQUENCY:TRIG 55 The frequency will change to 55 Hz if the MODE is set for STEP or PULSe and a Trigger is initiated.

[SOURce:]FREQuency:TRIGgered?

This query command will return the triggered frequency value.

Example
SOUR:FREQ:TRIG?

Responses:
<NR2>

[SOURce:]FREQuency:SLEW[:IMMediate]<sp><NRf>|MINimum|MAXimum

This command will set the frequency slew rate in Hz per second when the frequency source mode is FIXed.

initial:
MAXimum

Example:
FREQ:SLEW 20 The slew rate is 20 Hz per second.

[SOURce:]FREQuency:SLEW[:IMMediate]?

This query command will return the frequency slew rate for fixed mode frequency programming.

Example:
FREQ:SLEW?

Response:
<NRf>

[SOURce:]FREQuency:SLEW:MODE<sp>FIXed|STEP|PULSe|LIST

This command will define the source of the Frequency slew rate as follows

FIXed	Frequency is slew using the immediate slew rate value
STEP	Frequency is slew using the triggered slew value upon receiving a trigger.
PULSe	Frequency is slew using the triggered slew value upon receiving a trigger and for a duration defined by the PULSe.
LIST	Frequency is slew using the values defined by the LIST slew rate upon receiving a trigger command.

Initial:
FIXed

Example:
FREQ:SLEW:MODE LIST

[SOURce:]FREQuency:SLEW:MODE?

This query command will return the source of the frequency slew value.

Example:
FREQ:SLEW:MODE?

Response:
FIX | STEP | PULSe | LIST

[SOURce:]FREQuency:SLEW:TRIGgered <sp> <NRf>

This command will define the frequency slew rate when the mode is set for PULSe or STEP.

Initial:
MAXimum

Example:
FREQ:SLEW:TRIG 10

[SOURce:]FREQuency:SLEW:TRIGgered?

This query command will return the frequency slew rate.

Example
FREQ:SLEW:TRIG?

Response:
<NRf>

[SOURce:]PHASe <n> [:IMMediate] <sp> <NRf>

This command will program the phase angle of n with the numeric value specified by the NRf value. n is the phase number of 1, 2 or 3.

Initial:
Defined by the initial phase in the initial subsystem.

Examples:
PHASE2 240.0 set phase 2 angle to 240°
SOUR:PHAS3:IMM 120 set phase 3 angle to 120°

[SOURce:]PHASe<n>[:IMMediate]?

This query command will return the numeric value of phase n.

Examples:
PHASE2?
source:phase3?

Responses:
<NR2>

[SOURce:]PHASe<n>:MODE<sp>FIXed|STEP|PULSe|LIST

This command will control the source of the programmed phase as follows.

FIXed	Phase is updated immediately.
STEP	Phase is updated from the triggered value upon receiving a trigger.
PULSe	Phase is updated from the triggered value upon receiving a trigger and for a duration defined by the PULSe.
LIST	Phase is updated from the values defined by the LIST upon receiving a trigger command.

Initial:
FIXed

Example:
PHAS2:MODE FIXED

[SOURce:]PHASe<n>:MODE?

This query command will return the status of the phase mode FIX, STEP, PULSe or LIST.

Example:
PHASe1:MODE?

Responses:
FIX | STEP | PULS | LIST

[SOURce:]PHASe<n>:TRIGgered<sp><NRf>

This command sets the triggered phase value. The output phase will change to the triggered value when the mode is set to a STEP or PULSE upon receiving the trigger command.

Initial:
MINimum

Example:
PHAS1:TRIG 20

[SOURce:]PHASe<n>:TRIGgered?

This query command will return the phase n triggered value.

Example:
PHASe2:TRIG?

Response:
<NR2>

[SOURce:]FUNCtion<n>[:SHAPe][:IMMediate]<sp>SINusoid|SQUare|<trace>

This command will program the shape of the waveform of phase n to SIN, SQU or CSIN or trace. The trace functions will output a waveform shape that is described by the user-defined TRACe table.

Initial:
SIN

Examples:

FUNC:SHAP1 SIN	Set output waveform of phase 1 to sine wave.
SOUR:FUNC1:SHAPe 'WAVE1'	Set output waveform of phase 1 to a shape defined by user-defined trace WAVE1.

[SOURce:]FUNCtion<n>[:SHAPe][:IMMediate]?

This query command will return the shape of the waveform SIN, SQU, CSIN.

Examples:
FUNC1:SHAP?

Responses
SIN | SQU | <CRD>

[SOURce:]FUNCtion<n>[:SHAPe]:CSDIstortion<sp><NRf>

This command will program phase n waveform to a clipped sine wave with a percentage distortion specified by the NRf value. Both positive and negative peak amplitudes are clipped to a certain level to obtain the specified distortion level. Distortion level is 0 to 20% in 1% increments.

Initial
0 % distortion

Example:
FUNC1:SHAP:CSDI 10 10% distortion with a clipped sine wave

[SOURce:]FUNCtion<n>[:SHAPe]:CSDIstortion?

This query command will return the percentage distortion of clipped sine wave of phase n waveform.

Examples:
FUNC:CSDI?

Responses:
<NR2>

[SOURce:]VOLTage:RANGe<sp>LOW | HIGH

This command will set the output voltage range to the low or high range. The maximum value of the high and low voltage range is determine from the value of the voltage limit set by the limit vrange in the limit subsystem.

Initial:
Defined by the INIT:VOLT in the initial subsystem.

Example:
SOUR:VOLT:RANG LOW

[SOURce:]VOLTage<n>:RANGe?

This query command will return the value of the voltage range?

Example:
VOLT1:RANGe?

Response:
HIGH | LOW

[SOURce:]VOLTage<n>[:LEVel][:IMMediate][:AMPLitude]<sp><NRf>

This command will program the output voltage of phase n with the numeric value defined by the NRf.

Initial:
Defined by the initial volt in the initial subsystem.

Example:
VOLTage1 100

[SOURce:]VOLTage<n>[:LEVel][:IMMediate][:AMPLitude] ?

This query command will return the value of the programmed output voltage of phase n.

Example:
VOLT1?

Response:
<NR2>

[SOURce:]VOLTage<n>[:LEVel]:MODE<sp>FIXed|STEP|PULSe|LIST

This command will control the source of the programmed voltage as follows.

FIXed	Voltage is updated from the immediate value.
STEP	Voltage is updated from the triggered value upon receiving a trigger.
PULSe	Voltage is updated from the triggered value upon receiving a trigger and for a duration defined by the PULSe
LIST	Voltage is updated from the values defined by the LIST upon receiving a trigger command.

Initial:
FIXed

Examples:
VOLT1:MODE FIX
VOLT2:MODE LIST

[SOURce:]VOLTage<n>[:LEVel]:MODE?

This query command will return the mode status of phase n voltage as FIX,STEP,PULSe or LIST.

Example:
VOLT2:MODE?

Responses:
FIX | STEP | PULS : LIST

[SOURce:]VOLTage<n>[:LEVel]:TRIGgered[:AMPLitude]<sp><NRf>

This command sets the triggered voltage value of phase n. The output voltage is programmed with the triggered value when the MODE is set for STEP or PULSe and the trigger is initiated.

Initial:
MINimum

Example:
VOLT1:TRIG 115 the voltage of phase 1 will change to 115 volt if the MODE is set for STEP or PULSe and a Trigger is initiated.

[SOURce:]VOLTage<n>[:LEVel]:TRIGgered[:AMPLitude]?

This query command will return the triggered voltage value.

Example
SOUR:VOLT3:TRIG?

Responses:
<NR2>

[SOURce:]VOLTage<n>:SLEW[:IMMediate]<sp><NRf>

This command will program the slew rate of the output voltage level of phase n with a value specified by NRf. Instantaneous voltage changes can be obtained by sending MAXimum.

Initial:
MAXimum

Example:
VOLT1:SLEW 10

[SOURce:]VOLTage<n>:SLEW[:IMMediate]?

This query command will return the immediate slew rate value of the output voltage.

Example:
VOLT1:SLEW?

Response:
<NRf>

[SOURce:]VOLTage<n>:SLEW:MODE<sp>FIXed|STEP|PULSe|LIST

This command will define the source of the voltage slew rate of phase n as follows:

FIXed	Voltage is slew using the immediate slew rate value.
STEP	Voltage is slew using the triggered slew value upon receiving a trigger.
PULSe	Voltage is slew using the triggered slew value upon receiving a trigger and for a duration defined by the PULSe.
LIST	Voltage is slew using the values defined by the LIST slew rate upon receiving a trigger command.

Initial:
FIXed

Example:
VOLT2:SLEW:MODE LIST

[SOURce:]VOLTage<n>:SLEW:MODE?

This query command will return the source of the voltage slew value.

Example:
VOLT1:SLEW:MODE?

Response:
FIX | STEP | PULSe | LIST

[SOURce:]VOLTage<n>:SLEW:TRIGgered<sp><NRf>

This command will define the voltage slew rate when the mode is set for PULSe or STEP

Initial:
MAXimum

Example:
VOLT2:SLEW:TRIG 10

[SOURce:]VOLTage<n>:SLEW:TRIGgered?

This query command will return the voltage slew rate.

Example:
VOLT1:SLEW:TRIG?

Response:
<NRf>

[SOURce:]CURRent:PROTection:DELay<sp><NRf>

This command will inhibit the current limit protection for an amount of time defined by the NRf value.

Initial:
0.010 seconds

Example:
CURR:PROT:DEL 0.1 Set the current limit delay to 100 msec.

[SOURce:]CURRent:PROTection:DELay?

This query command will return the value of the current limit protection delay in seconds.

Example
CURR:PROT:DEL?

Response:
<NR2>

[SOURce:]CURRent<n>[:LEVel][:IMMediate][:AMPLitude}<sp><NRf>

This command will program the current limit of phase n with a value specified with the NRf value.

Initial:
Defined by the INITial:CURRent in the INITial subsystem.

Example:
CURR1 11 Set current limit of phase 1 to 11 amps.

[SOURce:]CURRent < n > [:LEVel][:IMMediate][:AMPLitude]?

This query command will return the current limit value of phase n.

Example:
CURR1?

Response:
< NR2 >

[SOURce:]CURRent < n > [:LEVel]:MODE < sp > FIXed | STEP | PULSe | LIST

This command will control the source of the programmed current limit as follows.

FIXed	Current is updated immediately.
STEP	Current is updated from the triggered value upon receiving a trigger.
PULSe	Current is updated from the triggered value upon receiving a trigger and for a duration defined by the PULSe.
LIST	Current is updated from the values defined by the LIST upon receiving a trigger command.

Initial:
FIXed

Examples:
CURR1:MODE FIX
CURR2:MODE LIST

[SOURce:]CURRent < n > [:LEVel]:MODE?

This query command will return the mode status of phase n current limit as FIX, STEP, PULSe or LIST.

Example:
CURR2:MODE?

Responses:
FIX | STEP | PULS | LIST

[SOURce:]CURRent < n > [:LEVel]:TRIGgered[:AMPLitude] < sp > < NRf >

This command sets the triggered current limit value of phase n. The output current limit is programmed with the triggered value when the MODE is set for STEP or PULSe and the trigger is initiated.

Initial:
MINimum

Example:
CURR1:TRIG 115 The current of phase 1 will change to 115 volt if the MODE is set for STEP or PULSe and a Trigger is initiated.

[SOURce:]CURRent < n > [:LEVel]:TRIGgered[:AMPLitude]?

This query command will return the triggered current limit value.

Example
SOUR:CURR3:TRIG?

Responses:
< NR2 >

5.5 LIMIT SUBSYSTEM

LIMit:PASSword < sp > < CRD >

This command is used to set the password to access the LIMIT configuration. This configuration is dependent on the power source rating and capabilities and must not be modified. The query command does not require the password.

Example:
LIM:PASS "23457CD"

LIMit:SAVe

This command is used to save the limit parameter in nonvolatile RAM.

Example:
LIMIT:SAVE

LIMit:FREQuency < sp > < NRf,NRf >

This command is used to set the upper and lower frequency limit.

Example:
LIM:FREQ 44,66 Set lower limit to 44 Hz and high limit to 66 Hz.

LIMit:FREQuency?

This query command will return the upper and lower frequency limits.

Example:
LIM:FREQ?

Response:
< NR2 > , < NR2 >

LIMit:VOLTage < sp > < NRf >

This command is used to set the upper voltage limit.

Example:
LIM:VOLT 270 Set voltage limit to 270 volt.

LIMit:VOLTage?

This query command will return the upper limit for voltage.

Example:
LIM:VOLT?

Response
< NR2 >

LIMit:CURRent < sp > < NRf >

This command is used to set the maximum current limit. This current is the sum of three-phase current at the low voltage range.

Example:
LIM:CURR 33 Set maximum current limit to 33 amps.

LIMit:CURRent?

This query command will return the current limit value.

Example:
LIM:CURR?

Response:
<NR2>

5.6 INITIAL SUBSYSTEM

INITial:SAVE

This command saves the initialization value in nonvolatile RAM.

Example:
INIT:SAVE

INITial:FREQuency<sp><NRf>

This command sets the initial frequency value. This value must be within the frequency limits set by the limits subsystem.

Example:
INIT:FREQ 60 Set the output frequency at power up for 60 Hz.

INITial:FREQuency?

This query command will return the initial frequency value.

Example:
INIT:FREQ?

Response:
<NR2>

INITial:VOLTage<sp><NRf>

This command will set the initial voltage value.

Example
INIT:VOLT 5 Set the output voltage at power up to 5 volts.

INITial:VOLTage?

This query command will return the initial voltage value.

Example:
INIT:VOLT?

Response:
<NR2>

INITial:PHASe<n>[:ANGLe]<sp><NRf>

This command will set the initial phase angle for phase n.

Examples:

INIT:PHAS2 240	Set phase 2 to 240° at power up.
INIT:PHAS3 120	Set phase 3 to 120° at power up.

INITial:PHASe<n>[:ANGLe]?

This query command will return the initial phase angle value.

Example:
INIT:PHAS2?

Response:
<NR2>

INITial:VRANge<sp>LOW|HIGH

This command will set the initial voltage range to a high or low voltage range. The high voltage range will equal the maximum voltage range set by the voltage limit value. The lower voltage range is equal to half the voltage set by the voltage limit value.

Example:
INIT:VRAN LOW

INITial:VRANge?

This query command will return the initial voltage range:

Example:
INIT:VRAN?

Response:
HIGH | LOW

INITial:CURRent <sp> <NRf>

This command sets the initial current limit value which must not exceed the maximum current limit at the initial voltage range and initial mode.

Example:
INIT:CURR 11.2

INITial:CURRent?

This query command will return the initial current limit value.

Example:
INIT:CURR?

Response:
<NR2>

INITial:MODE?

This query command will return the initial configuration of the power source as a single-phase or as a parallel-phase. The initial configuration is controlled by the hardware.

Example:
INIT:MODE?

Response:
ONE | THR

5.7 TRACE SUBSYSTEM

TRACe:CATalog?

This query command will return a comma-separated list of strings which contains the names of all traces.

Example:
Trace:cat?

Response:
<CRD>[,<CRD>] .....[,<CRD>]

TRACe:FREE?

This query command will return the amount of used memory space and available memory space for traces, in the following format <byte available>, <bytes in use>, where the return data for both shall be in <NR1> format.

Example:
TRACe:FREE?

Response:
<NR1>,<NR1>

TRACe:DEFine <sp> <trace_name> [,(numeric_value> | <trace_name>)]

This command allocates and initializes a new trace. The first parameter is <character data>, and it specifies the new <trace name>. If the second parameter is a <numeric value>, a new trace is allocated with specified number of elements. If the second parameter is a name of existing trace, the new trace becomes a copy of the existing trace in all respects, include size and content. The number of elements must be 4096.

Example:
TRAC:DEF "Wave1", "Wave2"
Defines Wave1 as a new trace that is identical to the trace wave2.

TRAC:DEF "waves"
This command will define waves Trace and will allocate a 4096 data point (8192 bytes)

TRACe:DEFine? <sp> <trace_name>

This query command will return the number of data points for the trace name.

Example:
TRAC:DEF? "wave1"

Response:
<NR1>

TRACe[:DATA] <sp> <trace_name>,(<trace_name> | <block> | <numeric_value> [,<numeric_value>]

This command will set the data values in the destination trace. If the data source is a trace name, the data is copied into the destination trace. If the data source is a block of data, then the block is directly loaded into the destination trace. If the data is a simple <numeric value>, every element of the destination trace is set to the constant value represented by the evaluation of <numeric value>. The number of data elements must be 4096. The amplitude of each data element is a value within the range of -2048 to +2047. The waveform is normalized so that the peak of the waveform will equal the peak of the sine wave program value.

Example:

```
TRAC "wave1", "wave2"
TRAC "wave2", 1234,127,.....,1256
```

TRACe[:DATA]? <trace_name>

This query command will return the data values for the trace name.

Example:

TRAC? "wave4" will return the data value for the trace wave4.

TRACe:DELete[:NAME] <trace_name>

This command will delete the trace defined by the trace name.

Example:

```
TRAC:DEL "wave3"
```

TRACe:DELete:ALL

This command will delete all traces from the trace buffers.

Example

```
TRACE:DEL:ALL
```

5.8 LIST SUBSYSTEM

LIST:COUNt < sp > < NRf >

This command will define the number of times the list will be executed.

Initial:
1

Example:
LIST:COUNt 2

LIST:COUNt?

This query command will return the number of times the list will repeat itself.

Example:
LIST:COUN?

Response:
< NR1 >

LIST:STEP < sp > ONCE | AUTO

This command will set the list step mode to step once with every trigger or it will advance automatically after the first trigger paced by the Dwell time between the list points.

Initial:
AUTO

Example:
LIST:STEP AUTO

LIST:CURRent < n > [:AMPLitude] < NRf > [, < NRf >][, < NRf >] ....[, < NRf >]

This command will set the list amplitude data points for the current limit of phase n.

Example:

LIST:CURR1 2,3,4,5	Set the current limit data points for phase 1 to 2,3,4 and 5 Amps.

LIST:CURRent < n > [:AMPLitude]?

This query command will return the list data points for phase n current limit.

Example:
LIST:CURR1?

Response:
< NR2 > [, < NR2 >] .....[, < NR2 >]

LIST:CURRent < n > :POINts?

This query command will return the number of data points the current list has.

Example:
LIST:CURR1:POINT?

Response:
< NR1 >

Example:
LIST:CURR1:POIN? MAX

Response:
16 This is the maximum data points in a list.

LIST:DWELl[:TIMe] < NRf > [, < NRf >][, < NRf >] ....[, < NRf >]

This command will set the dwell time between data points in a list when the step mode is set for auto.

Example:
LIST:DWEL 2,3,2,4 Set the time between data points to 2,3,2 and 4 seconds.

LIST:DWELl:POINts?

This query command will return the number of dwell data points in a list.

Example:
LIST:DWEL:POIN?

Response:
< NR1 >

LIST:FREQuency[:LEVel][:AMPLitude] < sp > **< NRf > [, < NRf >][, < NRf >]....[, < NRf >]**

This command will set the data point sequence for the frequency list.

Example:
LIST:FREQ 47,50,60,66

LIST:FREQuency[:LEVel][:AMPLitude]?

This query command will return the list data points for frequency.

Example:
LIST:FREQ?

Response:
< NR2 > [, < NR2 >] .....[, < NR2 >]

LIST:FREQuency[:LEVel]:POINts?

This query command will return the data points in a frequency list.

Example:
LIST:FREQ:POIN?

Response:
<NR1>

Example:
LIST:FREQ:POIN? MAX

Response:
16

LIST:FREQuency:SLEW[:RATE] <sp> **<NRf>[,<NRf>]....[,<NRf>]**

This command will set the frequency slew rate sequence data points.

Units:
Hz/Sec

Example:
LIST:FREQ:SLEW 2 — Set the frequency slew rate between data points in a list to 2 Hz/Sec.

LIST:FREQuency:SLEW[:RATE]?

This query command will return the frequency slew rate sequence data points in a list.

Example:
LIST:FREQ:SLEW?

Response:
<NRf>[,<NRf>]....[,<NRf>]

LIST:FREQuency:SLEW:POINts?

This query command will return the number of frequency slew points in a list.

Example:
LIST:FREQ:SLEW:POIN?

Response:
<NR1>

LIST:PHASe<n>[:ANGLe]<sp><NRf>[,<NRf>][,<NRf>] ....[,<NRf>]

This command will set the data points sequence of phase n angle of a list.

Example:
LIST:PHAS2 117,120,123 Set phase2 angle data points to 117°, 120° and 123°

LIST:PHASe<n>[:ANGLe]?

This command will return the phase n angle data points sequence in a list.

Example:
LIST:PHAS2?

Response:
<NR2>[,<NR2>] .....[,<NR2>]

LIST:PHASe<n>:POINts?

This query command will return the phase n number of data points in the list.

Example:
LIST:PHAS2:POINts?

Response:
<NR1>

LIST:VOLTage<n>[:LEVel][:AMPLitude]<sp><NRf>[,<NRf>][,<NRf>] ....[,<NRf>]

This command will set the data point for the voltage list.

Example:
LIST:VOLT1 108,115,122

LIST:VOLTage<n>[:LEVel][:AMPLitude]?

This query command will return the list data points sequence for voltage for phase n.

Example:
LIST:VOLT1?

Response:
<NR2>[,<NR2>] .....[,<NR2>]

LIST:VOLTage<n>[:LEVel]:POINts?

This query command will return the number of data points in phase n voltage list.

Example:
LIST:VOLT2:POIN?

Response:
<NR1>

Example:
LIST:VOLT1:POIN? MAX

Response:
16

LIST:VOLT<n>:SLEW[:RATE]<sp><NRf>[,<NRf>]....[,<NRf>]

This command will set phase n voltage slew rate between data points.

Units:
Volts/Sec

Example:
LIST:VOLT1:SLEW 2 Set the frequency slew rate between data points in a list to 2Volt/Sec.

LIST:VOLTage<n>:SLEW[:RATE]?

This query command will return phase n slew rate between data points in a list.

Example:
LIST:VOLT1:SLEW?

Response:
<NRf>[,<NRf>]....[,<NRf>]

LIST:VOLTage<n>:SLEW:POINts?

This query command will return the number of phase n voltage slew points in a list.

Example:
LIST:VOLT1:SLEW:POIN?

Response:
<NR1>

LIST:TTLTrg[:SWITch]<sp>OFF|ON

This command will enable or disable the output trigger for each of the data points in the List.

Initial:
On for one data point

Example:
LIST : TTLT ON, OFF, ON

LIST:TTLTrg[:SWITch]?

This query command will respond with the status of output trigger for each data point in the list.

Example:
LIST:TTLT?

Response:
<bool>[,<bool].....[,<bool>]

LIST:TTLTrg:POINts:

This query command will respond with a number of points of output trigger in the list.

Example:
LIST:TTLT:POIN?

Response:
<NR1>

5.9 PULSE SUBSYSTEM

PULSe:COUNt < sp > < NRf >

This command will define the number of times the pulse repeats itself.

Example:
PULSe:COUNt 2

PULSe:COUNt?

This query command will return the number of times the pulse will repeated when the trigger occurs.

Example:
PULS:COUN?
Response:
< NR1 >

PULSe:DCYCle < sp > < NRf >

This command will set the time delay between the trigger command and the start of the pulse sequence.

Initial:
0 sec

Example
PULS:DCYC 2 Set the delay to two seconds.

PULSe:DCYCle?

This query command will return the delay time between the trigger command and the pulse sequence.

Example:
PULS:DCYC?

Response:
< NR2 >

PULSe:PERiod < sp > < NRf >

This command will set the pulse period.

Initial
1 sec

Example:
PULS:PER 2 Set the pulse period for 2 seconds.

PULSe:PERiod?

This command will return the pulse period.

Example:
PULS:PER?

Response:
< NR2 >

PULSe:WIDTh < sp > < NRf >

This command will set the pulse width. The pulse width will track the pulse period to maintain the duty cycle.

Initial
0.5 sec

Example:
PULS:WIDT 1 Set the pulse width to 1 second.

PULSe:WIDTh?

Example:
PULS:WIDT?

This command will return the pulse width.

Response:
< NR2 >

FAULT:SOURCE

In the event the controller detects a fault, the output voltage will go to zero voltage. The above command will be used to find the source of fault. The format of the data returned is a bit filed decimal. The following are the Fault Errors and the corresponding decimal value:

Phase 1(A) Voltage fault	1
Phase 2(B) Voltage fault	2
Phase 3(C) Voltage fault	4
Temperature fault	8
Phase 1(A) Current limit fault	16
Phase 2(B) Current limit fault	32
Phase 3(C) Current limit fault	64

Example:

FAULT:SOURCE?

Response:

6 The response indicates a Voltage fault for both phase 2 and 3.

5.10 TRIGGER SUBSYSTEM

TRIGger:ABORt

This command will abort the trigger.

Example:

TRIG:ABOR

TRIGger:STATe?

This query command will respond with the state of the trigger. The only possible responses are IDLE, wait for ARM and BUSY.

Example:

TRIG:STAT?

Response:

IDLE ¦ WARM ¦ BUSY

TRIGger:INITiate[:IMMediate]

This command will initiate the trigger command upon execution of the trigger statement.

Example:
TRIG:INIT

TRIGger:INITiate:CONTinuous < sp > ON|OFF

This command will enable or disable the trigger in continuous mode. If the continuous mode is on, the list execution will continue after the first step and the dwell time will define the time between data points. If the continuous is off, the list will not advance to the next sequence until another trigger is initiated.

Default:
ON

Example:
TRIG:INIT:CONT ON

TRIGger:INITiate:CONTinuous?

This query command will return the status of the trigger.

Example:
TRIG:INIT:CONT?

Response:
ON|OFF

TRIGger:ARM[:IMMediate]

This command will arm the trigger subsystem.

Example:
TRIG:ARM

TRIGger:ARM:SOURce < sp > BUS|IMMediate

This command will define the trigger arm source. If the trigger source is Bus a Group Execute Trigger will initiate the trigger

Example:
TRIG:ARM:SOUR BUS

TRIGger:ARM:SOURce?

This query command will return the source of the trigger.

Example:
TRIG:ARM:SOUR?

Response:
BUS | IMM

TRIGger:TRIGger:SOURce < sp > **IMMediate | INTernal**

This command will define the trigger source. If internal is set, the trigger system will wait for the trigger phase angle. If the trigger is immediate the action is immediate.

Example:
TRIG:TRIG:SOUR INT

The trigger will initiate at the proper phase angle specified by the trigger phase angle.

TRIGger:TRIGger:SOURce?

This query command will return the status of the trigger source.

Example:
TRIG:TRIG:SOURCE?
Response:
IMM | INT

TRIGger:TRIGger:PHASe < sp > **< NRf >**

This command will set the phase angle to trigger the trigger subsystem if the trigger is set to internal. This phase angle is relative to phase 1. Phase 2 and 3 in three-phase will change at the same time phase 1 changes but not at the same angle.

Example:
TRIG:TRIG:PHASE 90

TRIGger:TRIGger:PHASe?

This query command will return the phase angle at which phase 1 will trigger when the trigger is set to internal.

Example:
TRIG:TRIG:PHASE?

Response:
<NR2>

TRIGger:TRIGger:DELay <sp> **<NRf>**

This command will define the delay time between initiate the trigger and the actual transient trigger.

Units:
seconds

Example:
TRIG:TRIG:DEL 2

TRIGger:TRIGger:DELay?

This command will return the delay in seconds.

Example
TRIG:TRIG:DEL?

Response:
<NR2>

Define the trigger arm source. If the trigger source is Bus a Group Execute Trigger will initiate the trigger.

Example:
TRIG:ARM:SOUR BUS

5.11 MEASUREMENT SUBSYSTEM

MEASure|FETCh[:SCALar]:FREQuency?

This query command will return the measured frequency value.

Units:
Hz

Example:
MEAS:FREQ?

Response:
<NR2>

MEASure|FETCh[:SCALar]:PHASe<n>?

This query command will return the measured phase angle for phase n.

Units:
degrees

Example:
MEAS:PHAS2?

Response:
<NR2>

MEASure|FETCh[:SCALar]:CURRent:RANGe<sp><NRf>

This command will select the current measurement range. These ranges are 2, 4, 8 and 16 amps or 80 and 160 amps if the high current option is installed. The HGA will auto range between the 2 amp and 4 amp ranges. It, also, will auto range between the 8 amp and 16 amp ranges. The range command must be used to change ranges from the 4 amp range to the 8 amp range. All loads must be removed for the HGA to accept the range change command.

Example
MEAS:CURR:RANGE 8

The above command will change the current measurement range to the 8 amp range. The load must be removed if the previous range is the 2 amp or the 4 amp range.

MEASure|FETCh[:SCALar]:CURRent?

This query command will return the current range measurement setting.

Example:
MEAS:CURR:RANG?

Response:
<NR1>

MEASure|FETCh[:SCALar]:CURR<n>[:AC]?

This query command will return the measured rms current value of phase n.

Units:
amps.

Example:
MEAS:CURR2?

Response:
<NR2>

MEASure|FETCh[:SCALar]:CURR<n>:AMPLitude:MAX?

This query command will return the measured peak current value of phase n. Resetting the measurement circuit may be required with the rest command prior to starting the measurement depending on the application.

Units:
amps

Example:
MEAS:CURR2:AMPL:MAX?

Response:
<NR2>

MEASure|FETCh[:SCALar]:CURR:AMPLitude:CLEar

This command will reset and clear the peak measurement circuit.

Example:
MEAS:CURR:AMPL:CLEar

MEASure|FETCh[:SCALar]:CURR<n>:CREStfactor?

This query command will return the ratio of the measured peak current to the measured rms current of phase n.

Units:
ratio
Example:
MEAS:CURR1:CRES?

Response:
<NR2>

MEASure|FETCh[:SCALar]:CURR<n>:HARMonic[:AMPLitude]?<sp><NRf1>, <NRf2>

This query command will return a single measured current harmonic number specified by the NRf2 at the fundamental frequency specified by the NRf1.

Units:
amps

Example:
MEAS:CURR2:HARM? 60,3

The above example will measure the third harmonic of phase two current at 60 Hz fundamental frequency

Response:
<NR2>

MEASure|FETCh[:SCALar]:CURR<n>:HARMonic:THD?<sp><NRf>

This query command will return the ratio of the root sum square of all current harmonic up to the 49th harmonic to the fundamental in percentage format. The fundamental frequency is specified by the NRf value.

Units:
ratio

Example:
MEAS:CURR1:HARM:THD? 50

The above example will measure phase one total harmonic distortion of 50 Hz fundamental frequency.

Response:
<NR2>

MEASure|FETCh[:SCALar]:POWer<n>[:AC][:REAL]?

This query command will return the true power of phase n.

Units:
Kilowatts

Example:
MEAS:POW1?

Response:
<NR2>

MEASure|FETCh[:SCALar]:POWer<n>[:AC]:APParent?

This query command will return the product of voltage and current for phase n.

Units:
Kilo Volt-Amp

Example:
MEAS:POW2:APP?

Response:
<NR2>

MEASure|FETCh[:SCALar]:POWer<n>[:AC]:PFACtor?

This query command will return the ration of the true power to the product of current and voltage of phase n.

Unit
ratio

Example:
MEAS:POW1:PFAC?

Response:
<NR2>

MEASure|FETCh[:SCALar]:VOLTage<n>[:AC]?

This query command will return the measured rms voltage value of phase n.

Units:
Volts

Example:
MEAS:VOLT1?

Response:
<NR2>

MEASure|FETCh[:SCALar]:VOLTage<n>HARMonic?<sp><NRf1>,<NRf2

This query command will return a single measured voltage harmonic number specified by the NRf2 at the fundamental frequency specified by the NRf1.

Units:
volts

Example:
MEAS:VOLT1:HARM? 60,5

This example will measure the fifth harmonic of phase one voltage for a 60 Hz fundamental frequency.

Response:
<NR2>

MEASure|FETCh:ARRay:CURRent<n>:HARMonic[:AMPLitude]?<sp><NRf1>, <NRf2>

This query command will return an array of measured current harmonics. The highest harmonic number is specified by the NRf2 value at the fundamental frequency specified by the NRf1.

Units:
amps

Example:
MEAS:ARR:CURR1:HARM? 60,9

The above example will measure the array of phase one current harmonic up to the ninth harmonic and to include the fundamental for a 60 Hz fundamental frequency.

Response:
<NR2>,<NR2>,.....<NR2>

MEASure|FETCh:ARRay:VOLTage<n>:HARMonic[:AMPLitude]?<sp><NRf1>,<NRf2>

This query command will return an array of measured voltage harmonics. The highest harmonic number is specified by the NRf2 value at the fundamental frequency specified by the NRf1.

Units:
volts

Example:
MEAS:ARR:VOLT1:HARM? 60,9

This example will measure the array of phase one voltage harmonic up to the ninth harmonic and to include the fundamental for a 60 Hz fundamental frequency.

Response:
<NR2>,<NR2>,.....<NR2>

5.12 CALIBRATION SUBSYSTEM

CALibrate:SAVE

This command will save the calibration value for the output parameters only.

Example:
CAL:SAV

CALibrate:PHASe<n><sp><NRf>

This command will add a value specified by NRf to the phase n angle value.

Initial:
0°

Example
CAL:PHAS2 +2

CALibrate:PHASe<n>?

This query command will return the value of phase n calibration angle.

Example:
CAL:PHASe<n>?

Response:
<NR2>

CALibrate:STATe < sp > ON|OFF

This command will enable or disable the calibration.

Example:
CAL:STATE ON

CALibrate:STATe?

This query command returns the state of the calibration.

Example
CAL:STAT?

Response
ON|OFF

CALibrate[:MEASure]:CURRent < n > [:AC][:DATA] < sp > < NRf >

This command will Auto calibrate the rms current of phase n. The calibration will be completed when the measured value is equal to the NRf value.

Example:
CAL:CURR1 3.76

CALibrate[:MEASure]:CURRent < n > [:AC]:CONStant < sp > < NRf >

This command will update the calibration constant of the rms current to a value specified by the NRf value. This value is a constant range 0 to 255.

Example:
CAL:CURR2:CONStant 127

CALibrate[:MEASure]:CURRent < n > [:AC]:CONStant?

This query command will return the calibration constant for phase n current.

Example:
CAL:CURR3:CONS?

Response:
< NR1 >

CALibrate[:MEASure]:CURRent < n > :AMPLitude:MAXampl[:DATA] < sp > < NRf >

This command will Auto calibrate the peak current of phase n. The calibration will be completed when the measured value is equal to the NRf value.

Example:
CAL:CURR1:AMPL:MAX 3.7

CALibrate[:MEASure]:CURRent < n > :AMPLitude:MAXampl:CONStant < sp > < NRf >

This command will update the calibration constant of the peak current of phase n to a value specified by the NRf value.

Example:
CAL:CURR2:AMPL:MAX:CONS 120

CALibrate[:MEASure]:CURRent < n > :AMPLitude:MAXampl:CONStant?

This query command will return the calibration constant for phase n peak current.

Example:
CAL:CURR1:AMPL:MAX:CONS?

Response:
< NR1 >

CALibrate[:MEASure]:CURRent < n > :HARMonic[:DATA] < sp > < NRf1 > , < NRf2 >

This command will Auto calibrate the harmonic current of phase n. The harmonic frequency is specified by the NRf1 value. The calibration will be completed when the measured value is equal to the NRf2 value.

Example:
CAL:CURR2:HARM 60, 3

This command will calibrate the current harmonic at 60 Hz for 3 amps at that frequency.

CALibrate[:MEASure]:CURRent < n > :HARMonic:CONStant < sp > < NRf > , < NRf >

This command will update the calibration constant of the harmonic current of phase n to a value specified by the NRf value.

Example:
CAL:MEAS:CURR1:HARM:CONS 127,0
Currently the second value is not in use but required.

CALibrate[:MEASure]:CURRent < n > :HARMonic:CONStant?

This query command will return the calibration constant for phase n harmonic current.

Example:
CAL:CURR3:HARM:CONS?

Response:
< NR1 >

CALibrate[:MEASure]:POWer < n > [:AC][:DATA] < sp > < NRf >

This command will Auto calibrate the true power of phase n. The calibration will be completed when the measured value is equal to the NRf value.

Example
CAL:POW1 2.6 units in Kw

CALibrate[:MEASure]:POWer < n > [:AC]:CONStant < sp > < NRf >

This command will update the calibration constant of the true power to a value specified by the NRf value.

Example:
CAL:POW2:CONS 110

CALibrate[:MEASure]:POWer < n > [:AC]:CONStant?

This query command will return the calibration constant for phase n power.

Example:
CAL:POW:CONS?

Response:
< NR1 >

CALibrate[:MEASure]:VOLTage < n > [:AC][:DATA] < sp > < NRf >

This command will Auto calibrate the rms voltage of phase n. The calibration will be completed when the measured value is equal to the NRf value.

Example:
CAL:VOLT1 135

CALibrate[:MEASure]:VOLTage<n>[:AC]:CONStant<sp><NRf>

This command will update the calibration constant of the rms voltage to a value specified by the NRf value.

Example:
CAL:VOLT2:CONS 100

CALibrate[:MEASure]:VOLTage<n>[:AC]:CONStant?

This query command will return the calibration constant for phase n voltage.

Example:
CAL:VOLT:CONS?

Response:
<NR1>

CALibrate[:MEASure]:VOLTage<n>:HARMonic[:DATA]<sp><NRf1>,<NRf2>

This command will Auto calibrate the harmonic voltage of phase n. The harmonic frequency is specified by the NRf1 value. The calibration will be completed when the measured value is equal to the NRf2 value.

Example:
CAL:VOLT1:HARM 50, 135
Calibrate Harmonic voltage for phase 1 for 135 volt at 50 Hz.

CALibrate[:MEASure]:VOLTage<n>:HARMonic:CONStant<sp><NRf>,<NRf>

This command will update the calibration constant of the harmonic voltage of phase n to a value specified by the NRf value.

Example:
CAL:VOLT2:HARM:CONS 100,0
The second constant is not used but required.

CALibrate[:MEASure]:VOLTage<n>:HARMonic:CONStant?

This query command will return the calibration constant for phase n harmonic voltage.

Example:
CAL:VOLT2:HARM:CONS?

Response:
<NR1>

5.13 SCPI COMMON COMMANDS

***CLS**

No query format.

This command clears all event registers and the Status Byte register.

***ESE <NRf>**

Query Format NR1

This command programs the standard Event Status Enable register bits. The register determines which events in the standard Event Status Register cause the event summary bit (esb) in the status register to become set. All enable event bits are o'rd to form the summary bit.

The definition of the individual bits within the standard event status structure is shown below:

b7	b6	b5	b4	b3	b2	b1	b0
PON	0	CMD	EXEC	DDE	QRY	0	OPC

***IDN?**

Query format.

Arbitrary ASCII Response Data

Description

This query returns an ASCII string which identifies the HGA. The string contains four comma-separated fields.

Field 1: California Instruments
Field 2: <model number>
Field 3: <serial number>
Field 4: <firmware revision level>

***OPT?**

Query format

Arbitrary ASCII Response Data

This query returns information about options installed in the HGA. It returns an ASCII string containing five comma-separated fields for options installed. A zero in the field indicates the option is not installed. The following are the options.

3-PHASE
SEL_1/3_PH
OUTP_ RELAY
DROP_SWITCH
DUAL_VRANGE

***RST**

Query format

No query form

This command resets all programmable functions to a fixed initial state.

***RST** command does not clear any of the status registers. It also sets the trigger system to idle state by sending an implied ABORT command.

***SAV**

Query format: none

This command saves an instrument's state so that it can later be retrieved using ***RCL** command. The argument to ***SAV** is the state number. There are 4 states in the interface numbered 1 through 4. All states are saved in nonvolatile memory.

***RCL**

Query format: none

This command recalls an instrument state that was previously saved with the ***SAV** command. The argument to ***RCL** is the state number. There are 4 states numbered through 4.

***OPC**

Query format: <NR1>

This command causes the interface to set the **OPC** bit of the Standard Event Status register when all pending operations have been completed.

The query form of ***OPC?** causes the interface to return the number "1" when all pending operation has been completed.

***ESR**

Query format: <NR1>

This query command returns the Standard Event Status register and clears the register to 0.

The definition of the individual bits within the Standard Event Status structure is shown below:

b7	b6	b5	b4	b3	b2	b1	b0
PON	0	CMD	EXEC	DDE	QRY	0	OPC

PON - Power on

CMD - Command Error

EXEC - Execution Error

DDE - Instrument Dependent

QRY - Query Error

OPC - Operation Complete

***SRE<NRf>**

Query format: <NR1>

This command sets or returns the value of the Service Request Enable register. This register determines what bits in the Status Byte will be summed into the MSS/RQS summary bits. RQS is the service request bit which is cleared by a Serial Poll, while MSS is the Master Status Summary bit which is not cleared away when read. The Status Byte definitions are shown below:

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
-	mss/rqs	esb	mav	-	-	-	-

CAUTION

Voltages up to 480 VAC are available in certain sections of this power source. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied.

***STB?**

Query format: NR1

This query returns the value of the Status Byte register. This register contains summary bits of all the status structures in the interface. The bit definitions are shown below:

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
-	mss/rqs	esb	mav	-	-	-	-

NOTE: The serial poll also returns the Status Byte register but with the Request Service bit (RQS) at bit 6. Performing a serial poll clears the RQS bit but does not clear the MSS bit.

***TRG**

Query format: None

This command generates an Event Signal to any subsystem that has BUSS selection. It has the same effect as a Group Execute Trigger <GET>.

***TST?**

Query format: <NR1>

This query command causes the HGA to perform a self-test and report any errors. A zero return value indicates that all tests passed without error.

SECTION 6

CALIBRATION and ADJUSTMENT

6.0 GENERAL

This section details the adjustment and calibration procedure for the HGA to meet its specified electrical performance level with a specific power source. The calibration and adjustment are required periodically every 1 year unless otherwise specified.

The procedures used in this section to adjust and calibrate the GUI require the GUI software. All calibration commands are accessible from the SCPI command and do not require the GUI software. However, harmonic generation for gain adjustment requires the GUI software.

For details on how to use the GUI software refer to Section 8 of this manual.

6.1 TEST EQUIPMENT

The following equipment or their equivalents are required to calibrate the HGA.

6.1.1 Digital voltmeter(DVM), Fluke 8840A.
6.1.2 100mΩ current shunt.
6.1.3 Resistive load
6.1.4 Function generator Wavetek 182A
6.1.5 Phase angle meter Krohn-Hite 6500A
6.1.6 Distortion meter Hewlett Packard 339A
6.1.7 Oscilloscope Kikusui COS6100
6.1.8 PC 386 or 486 with Serial interface or GPIB interface.
6.1.9 Graphical User Interface (GUI)

Refer to Figure 6-2 for System Connection and instrument hookup.

6.2 OUTPUT VOLTAGE CALIBRATION

This adjustment must be done with the power supply connected to the HGA. Refer to the HGA and Power Source manual Installation sections.

The top cover of the HGA must be removed to access to the adjustment pot.

Refer to Figure 6-1 for location of test points on the A4 board.

6.2.1 Program all three phases for full scale voltage at the low voltage range (135 Volts for standard configuration). Program the output frequency for 50 Hz.

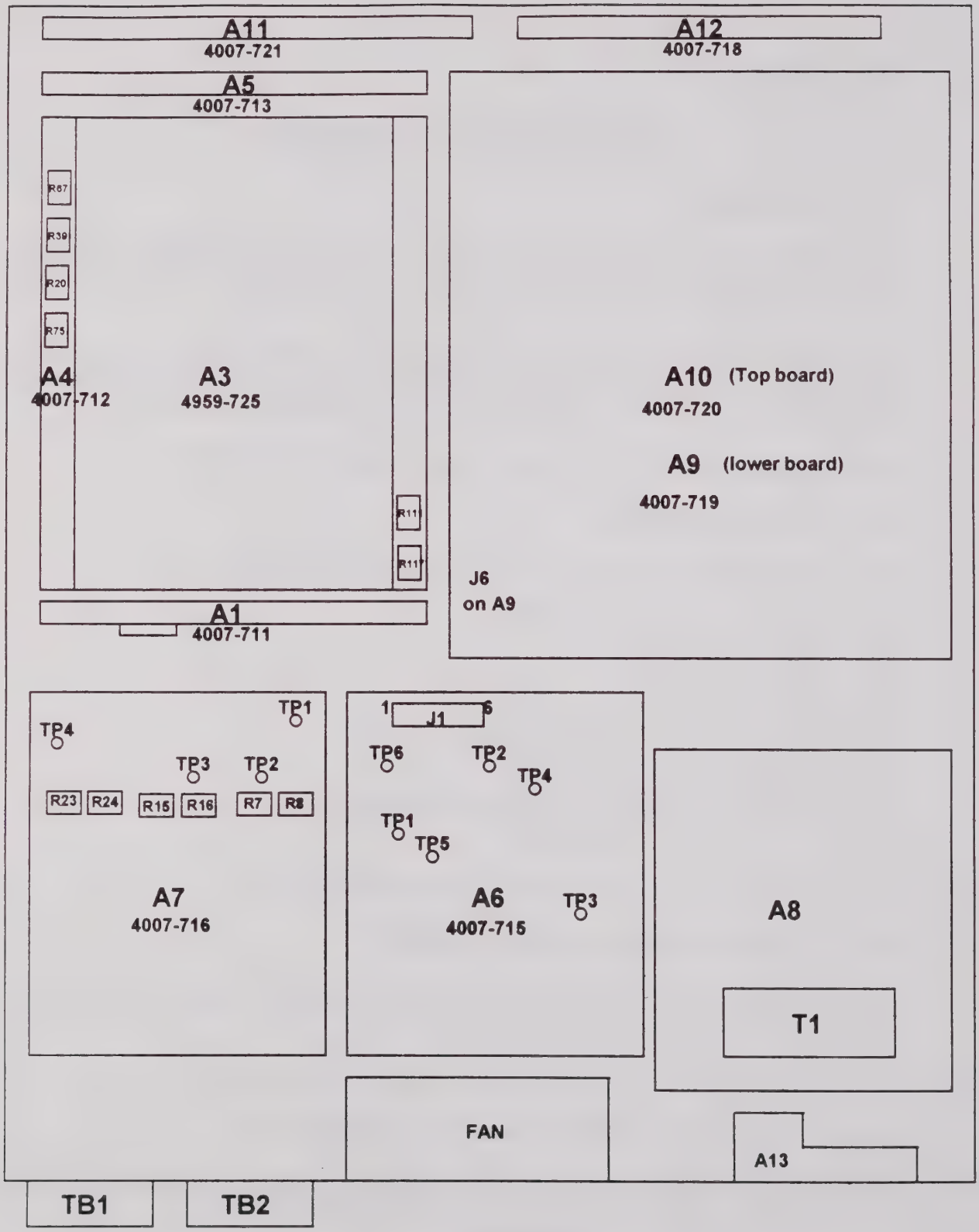
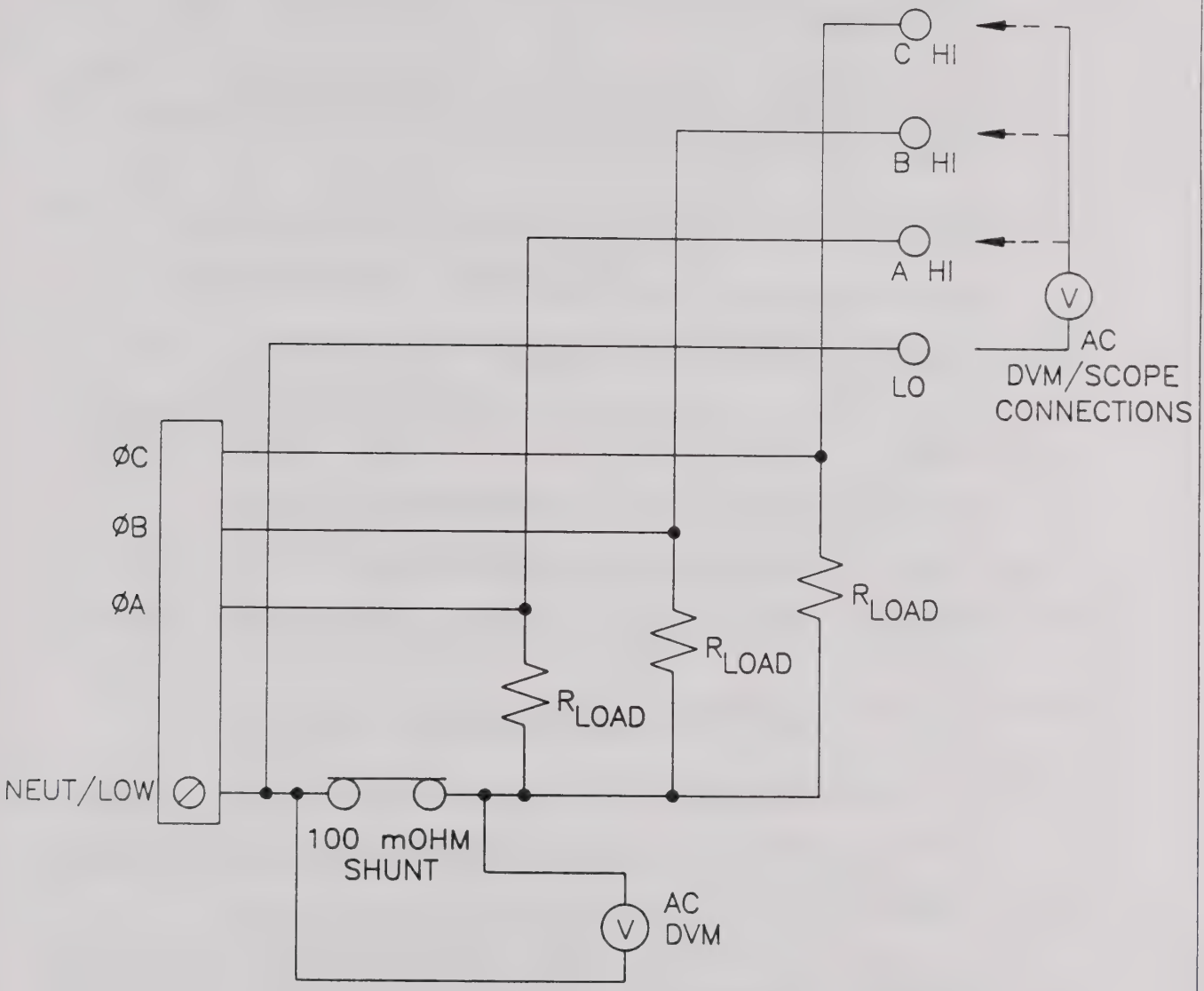

A11
4007-721
A12
4007-718
A5
4007-713
R67
R39
R20
R75
A4
4007-712
A3
4959-725
R111
R117
A1
4007-711
A10 (Top board)
4007-720
A9 (lower board)
4007-719
J6
on A9
TP1
TP4
TP3
TP2
R23
R24
R15
R16
R7
R8
A7
4007-716
1
J1
6
TP6
TP2
TP4
TP1
TP5
A6
4007-715
TP3
A8
T1
FAN
A13
TB1
TB2

FIGURE 6-1



RLOAD IS THE RESISTIVE LOAD VALUE PER PHASE TO PRODUCE A FULL LOAD CURRENT. REFER TO AC SOURCE MANUAL FOR THE FULL LOAD CURRENT.

FIGURE 6–2
AC POWER OUTPUT FUNCTION TEST CONNECTIONS

6.2.2 Select the customer waveform screen from the GUI. Enter 100% in the 10th harmonic. All other harmonics must be at zero (include the fundamental). Select compute. When computation is completed, select WV10 and select send. When send is completed, return to the steady state screen.

6.2.3 From the Transient screen, select custom waveform and waveform 10. The output frequency will change to 500 Hz. Adjust R39, R67 and R111 for phase A, B and C respectively for full scale volts ±0.05 volts.

6.2.4 Select Sine wave. The output frequency will change to 50 Hz. Adjust R20, R75 and R117 for phase A, B and C respectively for full scale volts ±0.05 volts.

6.2.5 Repeat steps 6.2.3 and 6.2.4 if necessary.

6.3 CURRENT BURDEN ADJUSTMENT

Note: This adjustment is not required unless Current or Harmonic Current calibration is not successful.

For 80/160 Amp Current Ranges, follow Section 6.7 instead of this section.

Refer to Figure 6-1 for location of test points on the A7 board.

6.3.1 From the GUI Interface Command Line select the 2 amp range with the following command:

CAL:CURR1:RANGE 2 and select the SEND key.

6.3.2 Program the output voltage to 100 volts.

6.3.3 Apply resistive load on phase A to produce a 2 amp load current. To reach the exact value, increase or decrease the program voltage value. Connect the low input of the AC voltmeter to TP1.

6.3.4 Reference to Table 6-1. Connect the high end of the voltmeter to the test point for the proper phase. Adjust the resistor value for that range and for that phase so that the voltage at the test point measures 0.4 volts ±0.2 mv rms.

6.3.5 Repeat steps 6.3.3 and 6.3.4 for phase B and C.

6.3.6 Remove the load and change the current range to the 4 amps range with following command:

CAL:CURR4:RANGE 4

6.3.7 Repeat steps 6.3.3 and 6.3.4 for phase A, B and C with 4 amps load current.

	Phase A	Phase B	Phase C
Ref. TP1	TP2	TP3	TP4
2 Amps.	R7	R15	R23
4 Amps	R8	R16	R24

Table 6-1

6.4 MEASUREMENT CALIBRATION

To access the Calibration screen from the Main Menu, select the Configuration screen then select the Measurement calibration.

6.4.1 VOLTAGE CALIBRATION

6.4.1.1 Program the output voltage to 135 volts and close the output relay.

6.4.1.2 Measure the output voltage for phase A with an external voltmeter.

6.4.1.3 Enter the above value in the value window for phase A voltage and select Accept to start the calibration.

6.4.1.4 When calibration is completed, the GUI will return the value of the calibration coefficient in the coefficient window.

6.4.1.5 Repeat steps 6.4.1.2 through 6.4.1.4 for phase B and phase C.

6.4.2 CURRENT CALIBRATION

6.4.2.1 From the Interface screen verify that the current range is set for the 2 amps range with the following query: MEAS:CURR:RANGE?

6.4.2.2 Change the current range to 2 amps if necessary with the following command.

MEAS:CURR:RANGE 2

NOTE: Range change may not take effect if unit is under load.

6.4.2.3 Select the measurement calibration screen from the configuration screen.

6.4.2.4 Apply resistive load about 1.8 amps on phase A. With the external voltmeter, measure the voltage across the shunt and compute the actual current for phase A.

6.4.2.5 Enter the computed value in the value window for phase A rms current and select Accept to start the calibration.

6.4.2.6 When calibration is completed the GUI will return the value of the calibration coefficient in the coefficient window.

6.4.2.7 Repeat steps 6.4.2.4 through 6.4.2.6 for phase B and phase C

6.4.3 PEAK CURRENT CALIBRATION

6.4.3.1 From step 6.4.2.4 compute the peak current value by multiplying the value by 1.4142 ($\sqrt{2}$).

6.4.3.2 Enter the computed value above in the value window for phase A peak current and select Accept to start the calibration.

6.4.3.3 When calibration is completed the GUI will return the value of the calibration coefficient in the coefficient window.

6.4.3.4 Repeat steps 6.4.3.1 through 6.4.3.3 for phase B and phase C.

6.4.4 POWER CALIBRATION

6.4.4.1 For the same program voltage and load current in step 6.4.1 and 6.4.2, calculate the output power of phase A by multiply the external voltmeter reading of voltage and current. The calculated value must be in Kwatts.

6.4.4.2 Enter the computed value above in the value window for phase A power and select Accept to start the calibration.

6.4.4.3 When calibration is completed the GUI will return the value of the calibration coefficient in the coefficient window.

6.4.4.4 Repeat steps 6.4.4.1 through 6.4.4.3 for phase B and phase C.

6.4.5 HARMONIC FILTER TUNE UP and GAIN ADJUSTMENT

Note: This adjustment is not required unless harmonic calibration was unsuccessful.

Refer to Figure 6-1 for location of test points on the A5 board.

6.4.5.1 Filter Clock frequency must be adjusted first. This adjustment should be done once. Do not repeat this adjustment for phase B or C.

6.4.5.2 Program the output voltage for 135 volts and the output frequency for 60 Hz. From the calibration screen enter 60 in the frequency window at the harmonic calibration screen.

6.4.5.3 Enter 0 volts in the value window for phase A voltage harmonic and select Accept to start the filter calibration. Wait until calibration is completed. The GUI will return the value for the calibration coefficient. Disregard the value.

6.4.5.4 Select the Interface screen. From the immediate command line set the calibration coefficient for phase A voltage to 127 with the following command followed by the SEND key.

CAL:VOLT1:HARM:CONStant < sp > 127

6.4.5.5 Enter the following command to measure the fundamental followed by the SEND key.

MEAS:VOLT1:HARM? < sp > 60,1

6.4.5.6 Adjust R14 on 4007-713 Harmonic-Interface board.

6.4.5.7 Repeat steps 6.4.5.5 and 6.4.5.6 until the response reads 135 volts $\pm$0.2 volts.

6.4.6 VOLTAGE HARMONIC CALIBRATION

6.4.6.1 Select the Measurement Calibration screen from the Configuration screen. Enter 135 volts in the value window for phase A voltage harmonic ; enter 60 Hz in the frequency window. Select Accept to start the calibration of phase A.

6.4.6.2 When calibration is completed the GUI will return the value of the calibration coefficient in the coefficient window.

6.4.6.3 Repeat steps 6.4.6.1 for phase B and C.

6.4.7 CURRENT HARMONIC CALIBRATION

6.4.7.1 Remove all loads and select the 2 amps range by typing the following command from the interface screen :MEAS:CURR:RANGE 2.0 and select the SEND key

6.4.7.2 Apply a resistive load for 1.8 amps on phase A. Adjust the output voltage to produce the proper load current.

6.4.7.3 From the Measurement Calibration screen, enter 60 Hz in the frequency window. Enter the value of the measured current with the external voltmeter into the value window for phase A current harmonic. Select Accept to start current harmonic calibration of phase A.

6.4.7.4 When the calibration is completed the GUI will return the value of the calibration coefficient in the coefficient window.

6.4.7.5 Repeat steps 6.4.7.2 and 6.4.7.3 for phase B and C.

6.5 CURRENT LIMIT CALIBRATION

Refer to the manual for the AC source Calibration section for this adjustment if it is required.

6.6 LOAD BALANCE ADJUSTMENT

This adjustment is only required when the HGA is installed with the 4500L with single and three phase configuration. This adjustment is not required unless the amplifier has been repaired. Refer to the Calibration section of the AC power source manual if this calibration is required.

6.7 80/160 AMPS CURRENT RANGES (Option)

Refer to Figure 6-1 for location of test points on the A7 board.

6.7.1 If the option is installed, select the Interface screen and from the command line enter the following command.

MEAS:CURR:RANGE 80 and select SEND

6.7.2 Program the output voltage for 100 volts.

6.7.3 Apply resistive load on phase A to produce 30 Amps. To reach the exact value increase or decrease the program value. Connect the low input of the AC voltmeter to TP1.

6.7.4 Refer to Table 6-2. Connect the high end of the voltmeter to the test point for the proper phase. Adjust the resistor value for that range and for that phase so that the voltage at the test point measures 0.15 volts rms $\pm$0.5mV.

6.7.5 Repeat steps 6.7.3 and 6.7.4 for phase B and phase C.

6.7.6 Remove the load and change the range to the 160 amps range with the following command from the command line.

MEAS:CURR:RANG 160

6.7.7 Repeat steps 6.7.2 through 6.7.5 for a load current of 60 amps and adjust voltage at test points for 0.15 volts rms ±0.5 mV. Use Table 6-2 for proper test points and adjustment pots.

	Phase A	Phase B	Phase C
Ref. TP1	TP2	TP3	TP4
80 Amps	R7	R15	R23
160 Amps	R8	R16	R24

Table 6-2

SECTION 7

THEORY OF OPERATION

7.0 GENERAL

An explanation of the circuit within the HGA is given in this section. Refer to Figure 7-1 for a block diagram of the HGA.

7.1 OVERALL DESCRIPTION

Input power from the rear panel is routed through the power on switch and into an EMI filter and voltage selection to an A8 regulated power supply and an A6 unregulated power supply.

The two power supplies provide DC voltages to all the printed circuit boards of the HGA.

The following is a summary of the basic components of the HGA:

- Digital board and the Main processor, A10.
- Analog board has a three-waveform generator, A9.
- Auxiliary processor board for measurement, A3.
- Harmonic board for harmonic measurement, A5.
- Control board to control the output voltage regulation and accuracy, A4.
- Keypad board, A11.
- Display board, A12.
- Current Sense board, A9.
- Interconnect board provides connection between boards and interface connection to power sources.
- Regulated DC supply, A8, to supply power to the A9, A10 and A12 boards.
- Unregulated supply, A6, to supply power to A3, A4, A5 and A7 boards. It also supplies 5 volts to provide isolation for GPIB and RS232 located on the A9 board.

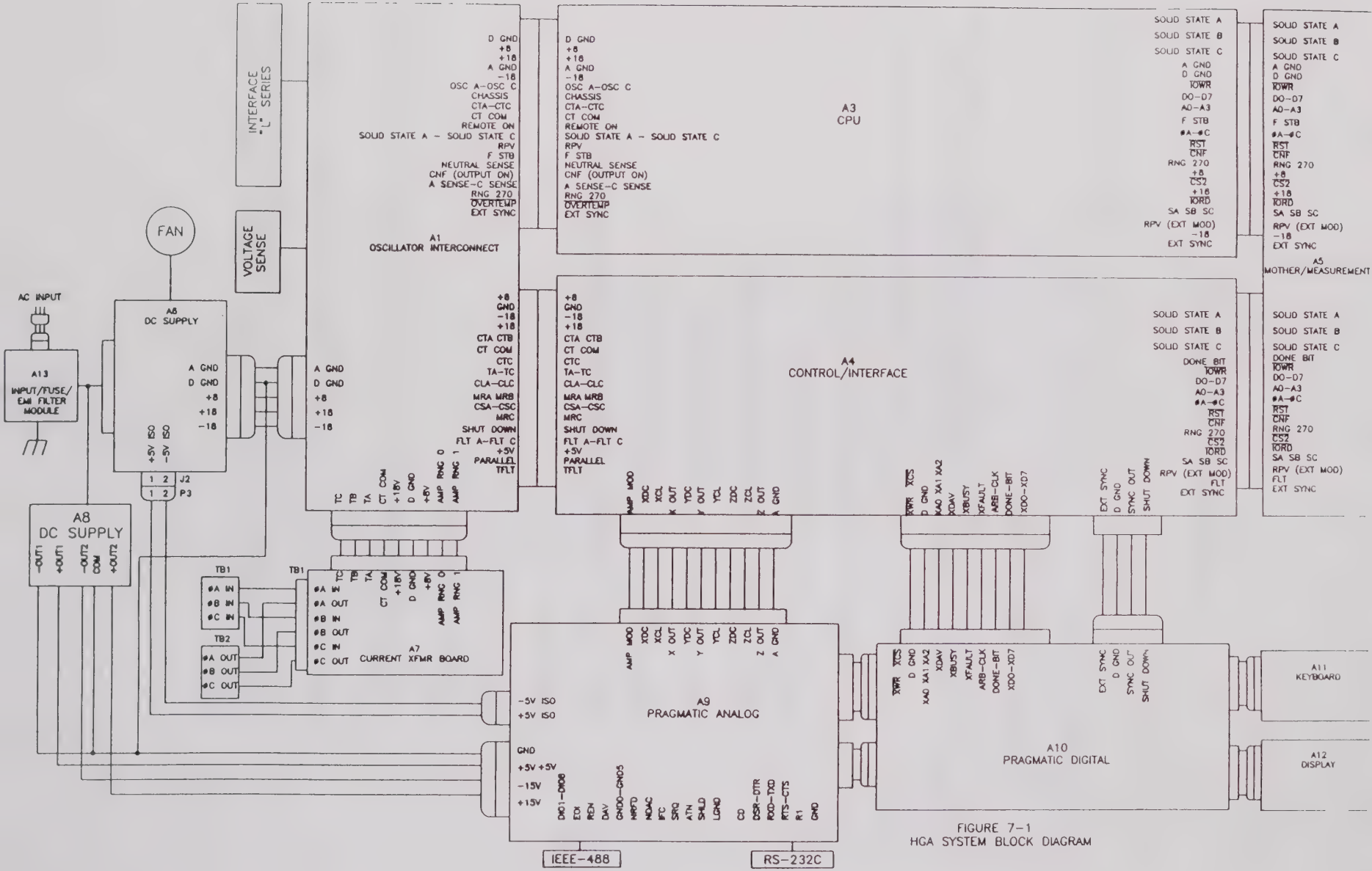


FIGURE 7-1
HGA SYSTEM BLOCK DIAGRAM

7.2 DIGITAL BOARD

The digital board contains the main processor. The main processor board receives SCPI commands from the IEEE488 interface or RS232 interface. It will process these commands and generate the appropriate response. It also scans the keypad and updates the display in local operation.

The digital board also will generate the frequency and the phase angle for the AC output signal.

7.3 ANALOG BOARD

This board has the optocoupler isolation for the IEEE488 and RS232 interface. The basic function is to generate the voltage programming reference and generate a waveform for all three phases. It will accept data from the digital board. This data has information about the voltage level, frequency value and phase angle for all three phases.

7.4 BASIC MEASUREMENT BOARD

This board has a microcontroller that will accept measurement and calibration commands from the main processor. It will translate this command and perform the measurement or calibration and report the result to the main processor.

7.5 HARMONIC MEASUREMENT BOARD

This board is an extension of the measurement board. It contains the hardware required to measure the harmonics and the peak current. This board utilizes a 4-stage programmable switch capacitor filter to measure the harmonic of a known fundamental.

7.6 CONTROL BOARD

This board has the parallel interface circuits that will allow the communication between the measurement processor and the main processor. It also has a control circuit for voltage accuracy and voltage regulation. It also has the logic to detect a fault condition if the output voltage does not agree with the program value.

7.7 CURRENT SENSE BOARD

This board contains the current transformers that sense the load current and generates a voltage signal proportionate to the load current. It has several ranges to select the proper signal level for accurate current and harmonic current measurements.

Refer to the theory of operation in the AC source user manual for the appropriate power source. Disregard any reference to the oscillator Theory of Operation in the AC source manual.

SECTION 8

GRAPHICAL USER INTERFACE

8.0 INTRODUCTION

Graphical User Interface is a software program operating under Microsoft "Windows"™ on the PC platform. The Graphical User Interface will be referred to as GUI. The GUI is a set of screens that allows the user to control the HGA functions such as harmonic analysis, waveform generation and transient generation of output voltage and frequency.

8.1 SYSTEM REQUIREMENT

GUI requires the following configuration.

- An IBM personal computer or 100% compatible running MS-DOS version 5 or later.
- An 80386 or higher processor.
- Four megabytes of memory.
- 2 Megabytes of available hard disk.
- Microsoft "Windows"™ graphical environment.
- RS232 port or GPIB Interface Adapter with appropriate drivers.

8.2 GUI INSTALLATION

1. Insert the distribution disk in drive A or drive B.
2. From the "Windows"™ Program Manager select RUN.
3. Type A:\SETUP if the distribution disk is in drive A or B:\SETUP if the distribution disk is in drive B.

8.3 RS232 INTERFACE

The RS232 Interface is a standard Interface in the PC. Use COM1 or COM2 port. Refer to Section 2.3.5 for cable connections between the HGA and the PC.

8.4 GPIB INTERFACE

The GPIB Interface requires a GPIB Interface adapter and appropriate driver to operate in the "Windows"™ environment. It is recommended using National Instrument AT-GPIB. Follow the manufacture's installation procedure.

8.5 INTERFACE CONFIGURATION

The following steps describe how to set the Listen Address for the GPIB and the RS232 configuration.

8.5.1 HGA SETUP

GPIB Address selection:

1. Turn power on for the HGA.

2. Press the UTILITY key and rotate the knob clockwise until the Utility:GPIB appears on the screen.

3. Press the right arrow twice. The GPIB address will appear on the screen.

4. Rotate the knob to select the desired GPIB address.

RS232 Configuration:

1. Turn power on for the HGA.

2. Press the UTILITY key and rotate the knob clockwise until the Utility:RS232 appears on the screen.

3. Press the right arrow twice. The baud rate will appear on the screen. Rotate the knob to select the desired baud rate.

4. Press the left arrow and rotate the knob clockwise once. The parity bit will appear on the screen. Press the right arrow once and verify that the parity is none. If not rotate the knob until the parity is none.

5. Press the left arrow once and rotate the knob clockwise once. The No. of Bits screen will appear on the screen. Press the right arrow once to review the number of bits. Rotate the knob left or right if the Bits does not equal 8D1S (8 data bits and 1 stop bits)

6. Press the left arrow once and rotate the knob clockwise once. The Handshake message will appear. Press the right arrow once. Rotate the knob in either direction until Handshake is HW. Press the UTILITY key and the VOLT key.

8.5.2 GUI SETUP

1. Double click on the HGA Icon. When the program is loaded click on the START button. Select the Interface screen from the menu.

For RS232 configuration:

2. Select COM port number and baud rate that matches the baud rate selected for the HGA.

For GPIB Address selection:

3. Click on the down arrow for the GPIB address and select the Listen Address for the GPIB. This address must match the address selected for the HGA control panel.

4. Click on CLOSE to go to the main menu selection

8.6 GUI OPERATION

8.6.1 GENERAL

1. Double click the HGA Icon to start the HGA. The introductory screen will appear with the HGA software revision appearing on the top of the screen. See Figure 8-1.

2. Click the Start Icon. The main menu will appear on the screen. See Figure 8-2. Select the GPIB or RS232 from the Interface block in the lower left corner.

3. The Main Menu has the following selection:

    1. Configuration screens
    2. Source screens
    3. Measurement screens
    4. Interface screen
    5. Custom waveform screen

8.6.2 CONFIGURATION SCREEN

Select the Configuration screen from the Main Menu screen. The configuration setup screen will appear. See Figure 8-3. This screen has information about the power source in use with the HGA and it is not user configurable.

The limit block defines the frequency range, the upper voltage range and the maximum current the AC source system can deliver on the low voltage range for all three phases.

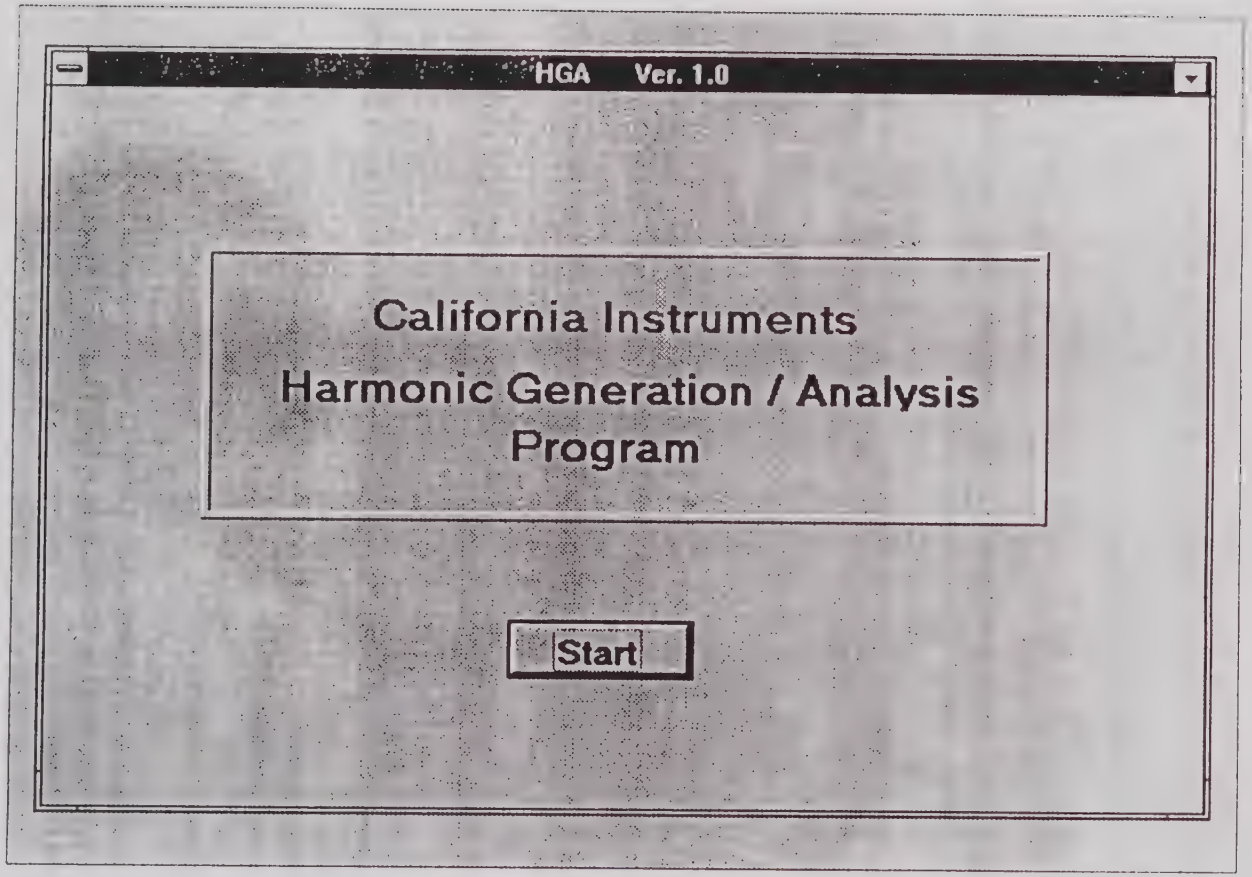

HGA Ver. 1.0
California Instruments
Harmonic Generation / Analysis
Program
Start

Figure 8-1

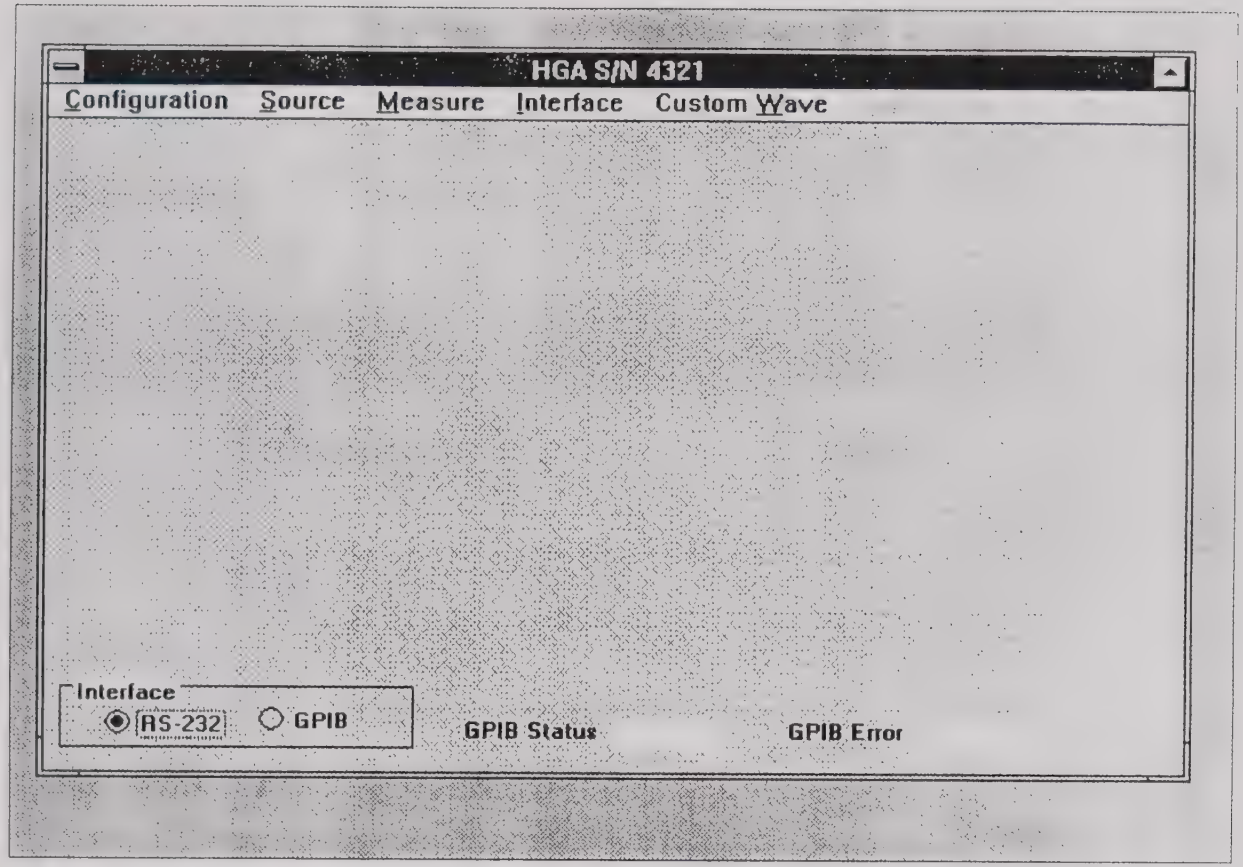

HGA S/N 4321
Configuration
Source
Measure
Interface
Custom Wave
Interface
RS-232
GPIB
GPIB Status
GPIB Error

Figure 8-2

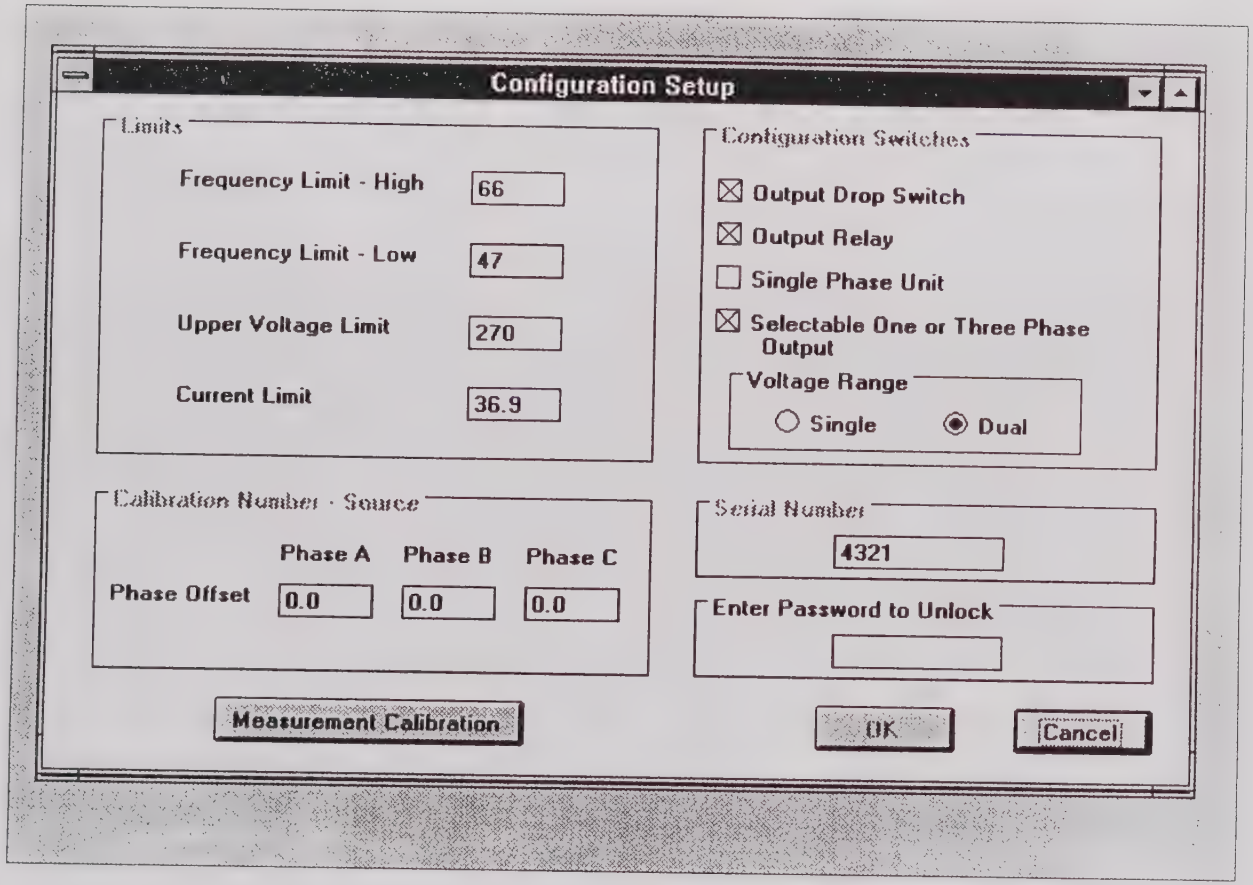

Configuration Setup
Limits
Frequency Limit - High
66
Frequency Limit - Low
47
Upper Voltage Limit
270
Current Limit
36.9
Configuration Switches
Output Drop Switch
Output Relay
Single Phase Unit
Selectable One or Three Phase Output
Voltage Range
Single
Dual
Calibration Number - Source
Phase A
Phase B
Phase C
Phase Offset
0.0
0.0
0.0
Serial Number
4321
Enter Password to Unlock
Measurement Calibration
OK
Cancel

Figure 8-3

The configuration switches define the options of the AC system. The (x) will indicate that the option is available.

The calibration block will allow an entry in degrees for output phase adjustment.

Selecting the measurement calibration box will lead to the measurement calibration screen. See Figure 8-4.

This screen will be used to Auto calibrate the various measurement functions for the HGA. A numeric value is entered in the value box. This value is equal to the external measurement standard and must be entered in units except power in Kwatts. One data value should be entered at a time followed by the Accept Icon key. When the calibration is completed, the calibration coefficient will be viewed in the coefficient window. There is no entry to this window. The user must clear the value window before another calibration sequence. The Accept Icon key will start the calibration of all the phases and functions that have a numeric value in its value window. Harmonic calibration requires entry of the fundamental frequency.

See Section 6 in this manual for Calibration Procedure.

8.6.3 SOURCE SCREENS

The SOURCE Menu has three screens from which to select:
System Setup Screen, Steady State Screen and Transient Screen.

8.6.3.1 System Setup Screen

The system setup screen controls the initial state at power up of output voltage, frequency, phase, current limit, voltage range and current limit hold up delay. See Figure 8-5. Use the slider or the numeric window to change the initial state power up parameter. Click the Save box to save the updated parameters.

8.6.3.2 Steady State Screen

This screen will control the output parameter of the power source driven by the HGA. See Figure 8-6. This screen will control the output relay, voltage range and single or three-phase configuration if the options are enabled. The output voltage, frequency, phase angle and current limit is controlled by moving the appropriate slider or updating the numeric data for each window. The output execution block controls the parameters update. The OK key selection requires clicking on the OK box to update the output parameters. If the immediate selection is made, the output parameters are updated immediately.

The waveform block is used to select the custom waveform.

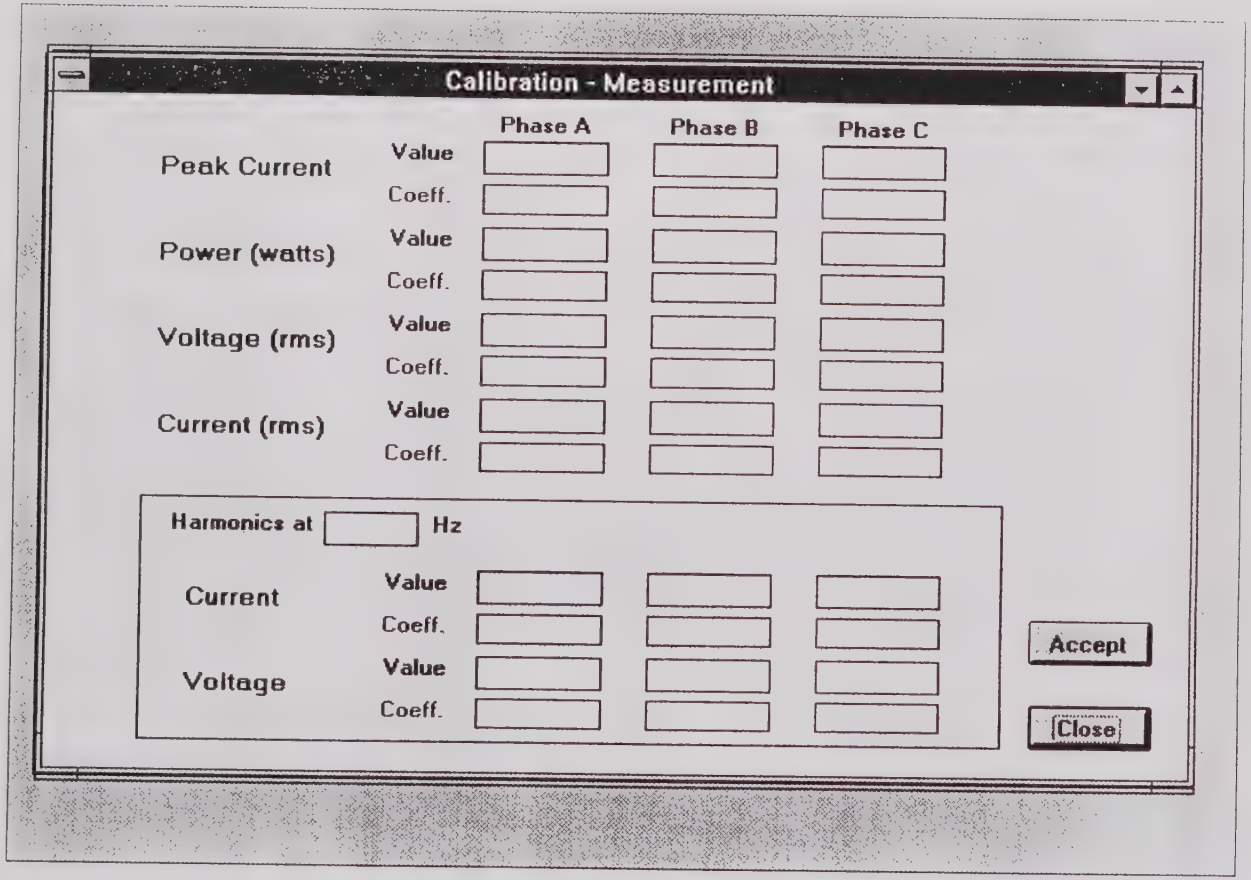

Calibration - Measurement
Phase A
Phase B
Phase C
Peak Current
Value
Coeff.
Power (watts)
Value
Coeff.
Voltage (rms)
Value
Coeff.
Current (rms)
Value
Coeff.
Harmonics at
Hz
Current
Value
Coeff.
Voltage
Value
Coeff.
Accept
Close

Figure 8-4

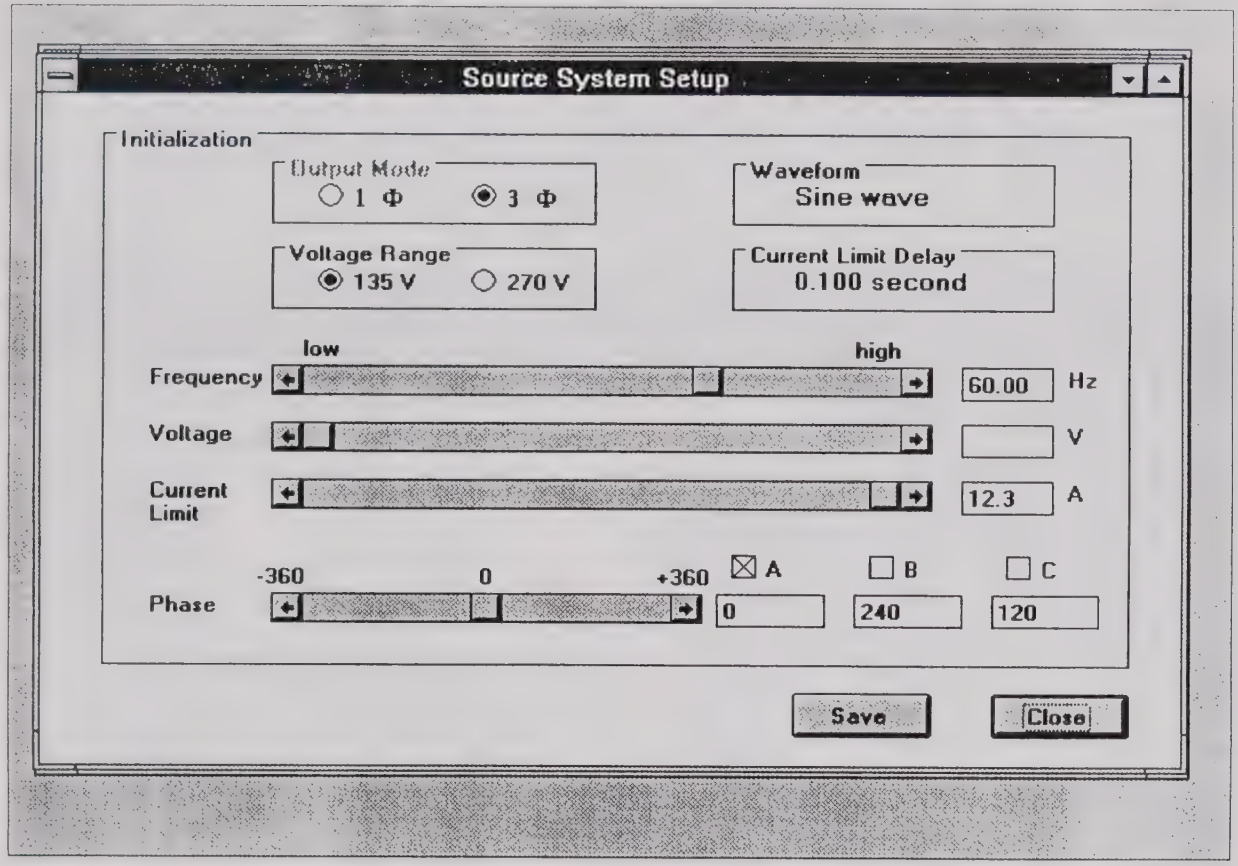

Source System Setup
Initialization
Output Mode
1 Φ
3 Φ
Waveform
Sine wave
Voltage Range
135 V
270 V
Current Limit Delay
0.100 second
low
high
Frequency
60.00
Hz
Voltage
V
Current Limit
12.3
A
-360
0
+360
A
B
C
Phase
0
240
120
Save
Close

Figure 8-5

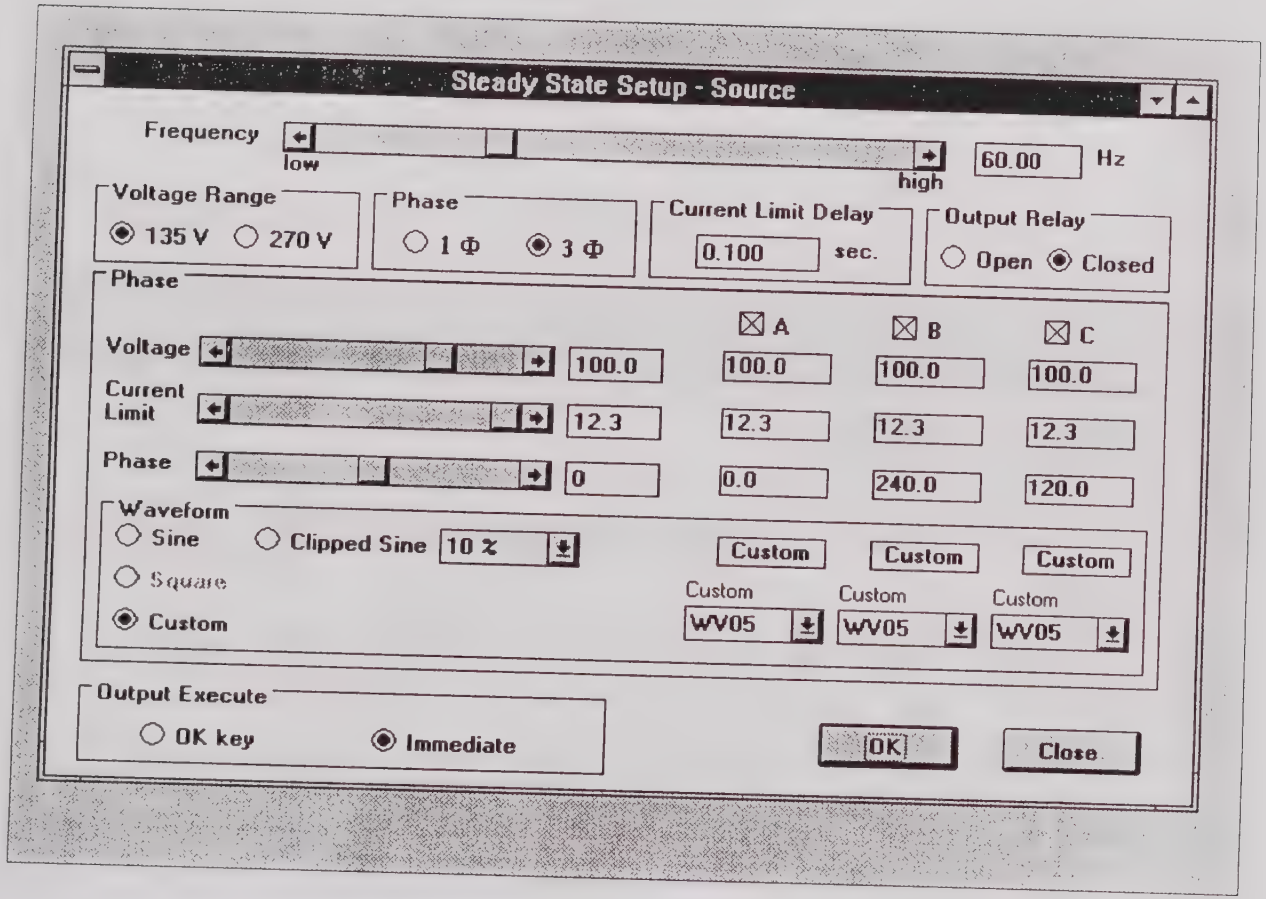

Steady State Setup - Source
Frequency
low
high
60.00
Hz
Voltage Range
135 V
270 V
Phase
1 Φ
3 Φ
Current Limit Delay
0.100
sec.
Output Relay
Open
Closed
Phase
A
B
C
Voltage
100.0
100.0
100.0
100.0
Current Limit
12.3
12.3
12.3
12.3
Phase
0
0.0
240.0
120.0
Waveform
Sine
Clipped Sine
10 %
Square
Custom
Custom
Custom
Custom
Custom
Custom
WV05
WV05
WV05
Output Execute
OK key
Immediate
OK
Close

Figure 8-6

8.6.3.3 Transient

This screens allow the generation of complex transients for both the voltage and frequency. See Figure 8-7. The transient screen has a maximum of 16 steps. The transient step types are Delay, Vsrg/sag, VDrop, VSweep, VStep, FSweep, FStep and VFSweep. Each step type has parameters associated with it such as Duration, Voltage Value, Frequency Value and Start Phase Angle. The number of valid parameters for each step type may not be the same. The GUI will not allow data entry unless the parameter is valid for the type of step. Figure 8-14 shows the Transient types.

8.6.4 MEASUREMENT

The measurement menu has four screens, Basic Measurement I, Basic Measurement II, voltage harmonic measurement and current harmonic measurement.

8.6.4.1 Basic Measurement I

Basic Measurement I will measure rms voltage, rms current true power, frequency and phase angle. Selection of functions and phases are required to define the active measurement parameter of the screen. The measurement could be activated once or continued depending on the Measurement option selection. Phase B and Phase C selections are disabled for single-phase configuration. Figure 8-8 shows this screen. Refer to paragraph 8.6.5.1 for current measurement range change if range change is required.

8.6.4.2 Basic Measurement II

Basic Measurement II will measure peak current, power factor, apparent power, and total harmonic distortion of both the current waveform and the voltage waveform. Selection of functions and phases are required to define the active measurement parameter of the screen. The measurement could be activated once or continue depending on the measurement option selection. Phase B and Phase C selections are disabled for single-phase configuration. Figure 8-9 shows this screen. Refer to paragraph 8.6.5.1 for current measurement range change if range change is required.

If the peak current measurement is the only function selected and for one phase only, the peak measurement will not reset after each measurement when the measurement is in continuous mode. To reset the peak current measurement after each measurement, select another function or select a single measurement.

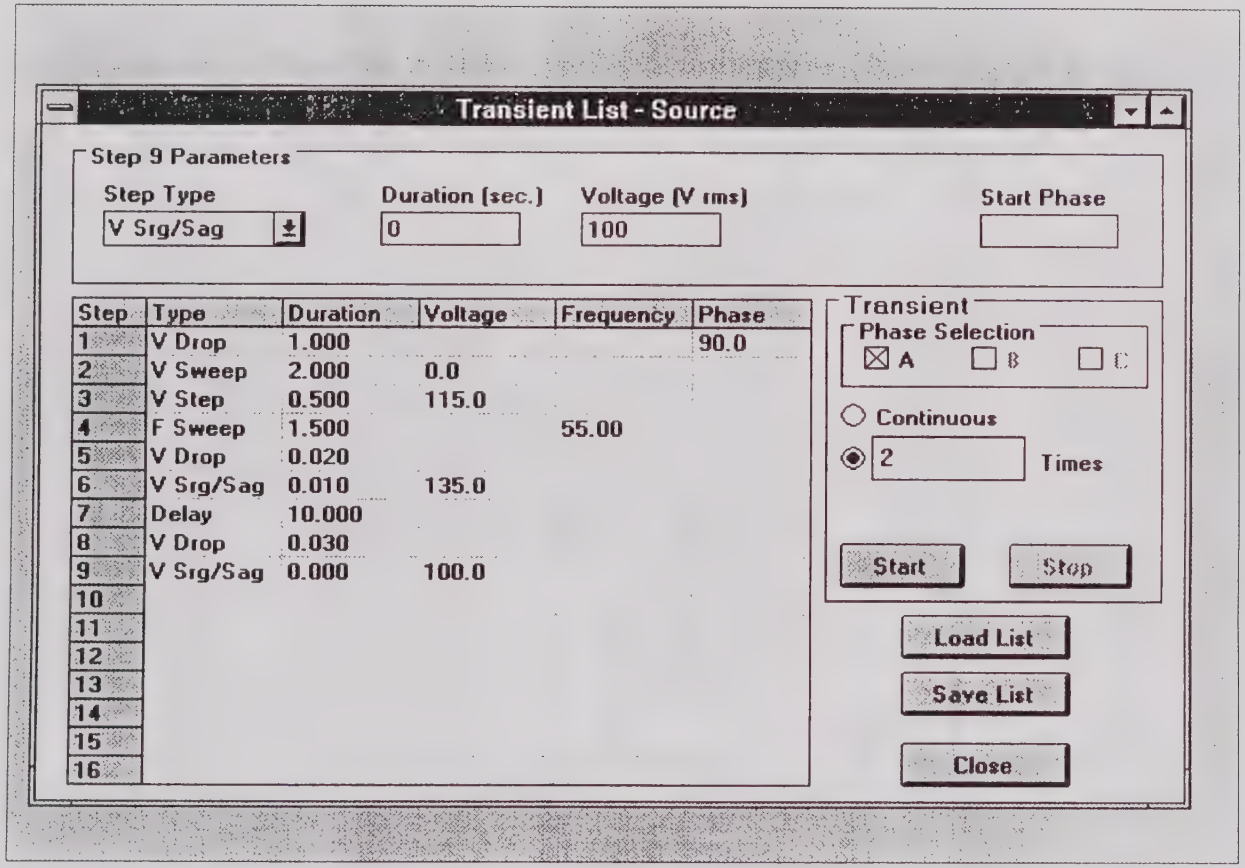

Transient List - Source
Step 9 Parameters
Step Type
V Srg/Sag
Duration (sec.)
0
Voltage (V rms)
100
Start Phase
Step | Type | Duration | Voltage | Frequency | Phase
1 | V Drop | 1.000 | | | 90.0
2 | V Sweep | 2.000 | 0.0 | |
3 | V Step | 0.500 | 115.0 | |
4 | F Sweep | 1.500 | | 55.00 |
5 | V Drop | 0.020 | | |
6 | V Srg/Sag | 0.010 | 135.0 | |
7 | Delay | 10.000 | | |
8 | V Drop | 0.030 | | |
9 | V Srg/Sag | 0.000 | 100.0 | |
10
11
12
13
14
15
16
Transient
Phase Selection
A
B
C
Continuous
2
Times
Start
Stop
Load List
Save List
Close

Figure 8-7

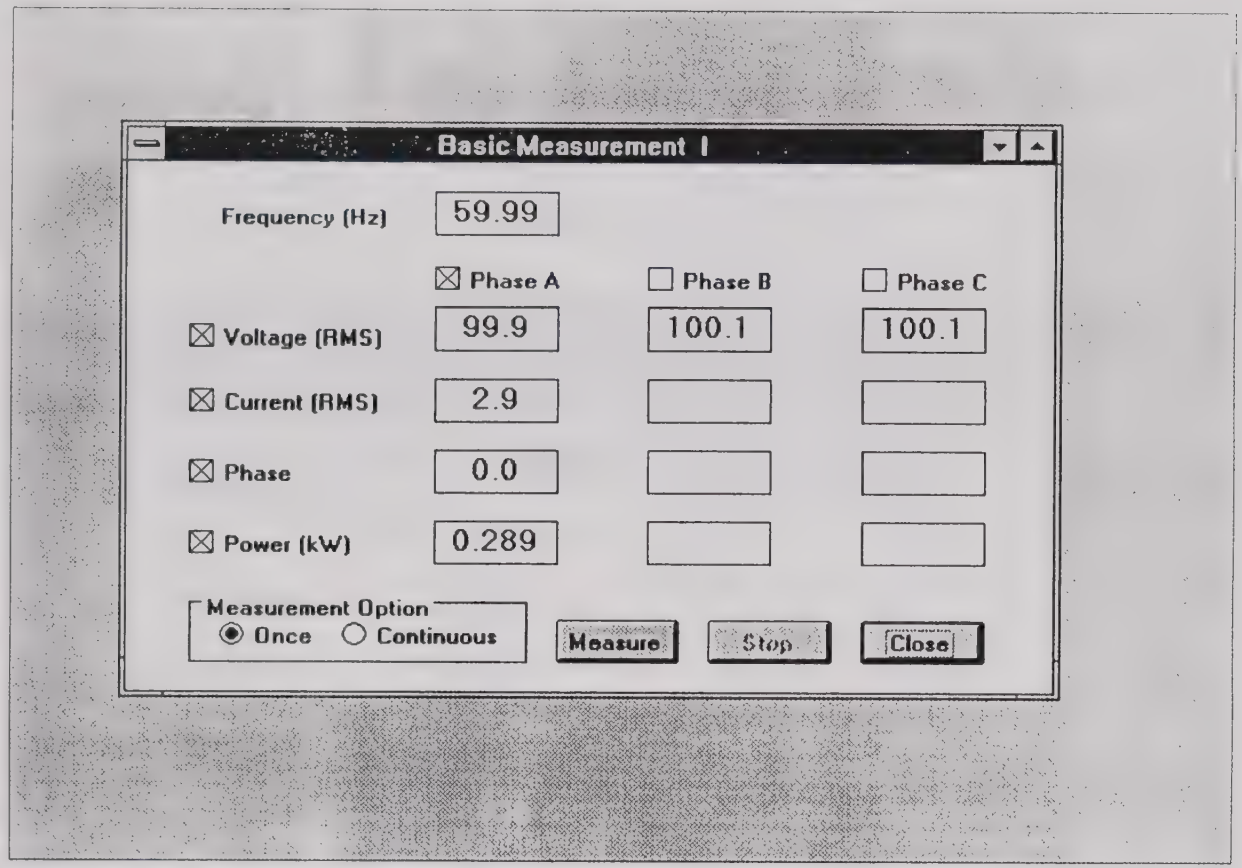

Basic Measurement I
Frequency (Hz)
59.99
Phase A
Phase B
Phase C
Voltage (RMS)
99.9
100.1
100.1
Current (RMS)
2.9
Phase
0.0
Power (kW)
0.289
Measurement Option
Once
Continuous
Measure
Stop
Close

Figure 8-8

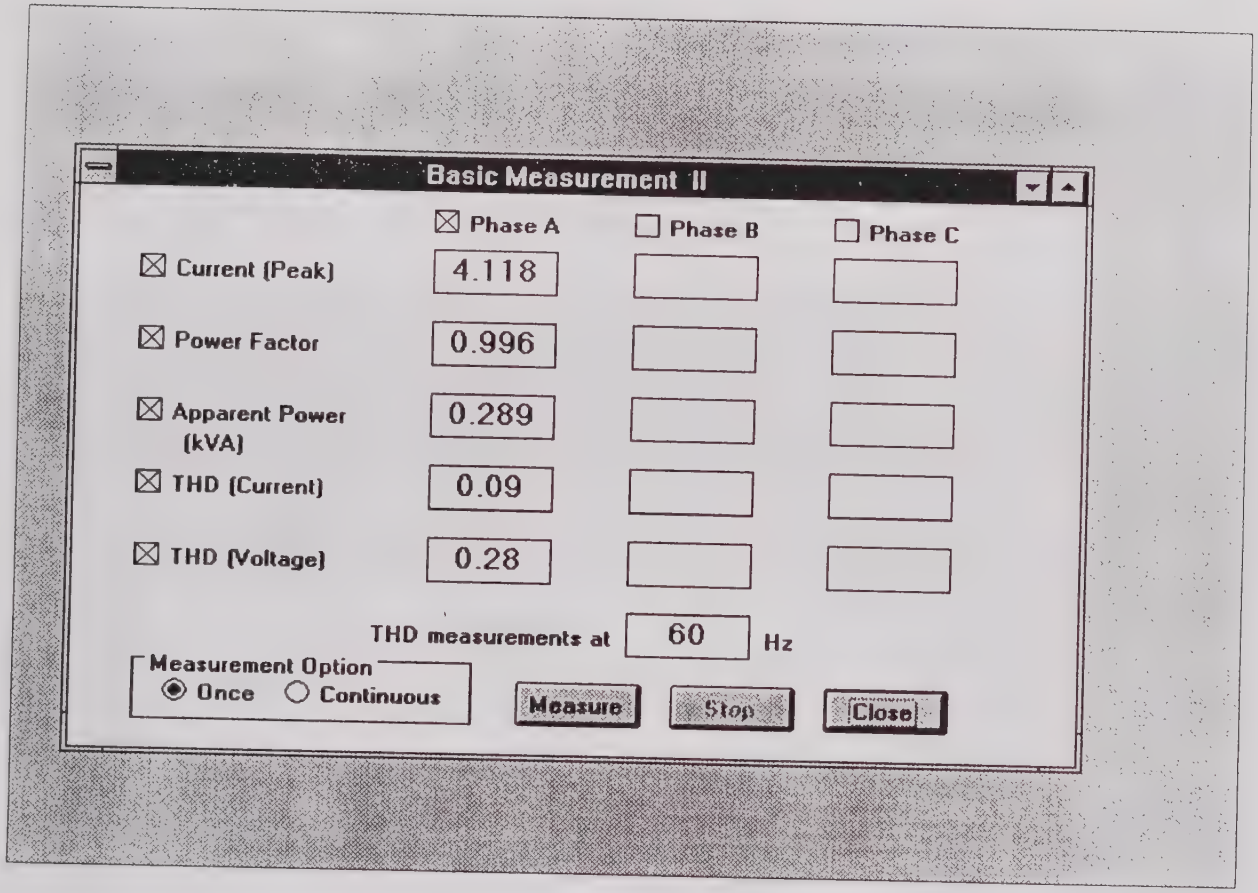

Basic Measurement II
Phase A
Phase B
Phase C
Current (Peak)
4.118
Power Factor
0.996
Apparent Power (kVA)
0.289
THD (Current)
0.09
THD (Voltage)
0.28
THD measurements at
60
Hz
Measurement Option
Once
Continuous
Measure
Stop
Close

Figure 8-9

8.6.4.3 Current Harmonic Measurement

This screen will measure the fundamental and all the harmonics up to the 49th harmonics of the current waveform for the selected phase in amps and compute the percentage of harmonic to the fundamental. Measurement result will not be viewed if the fundamental is at zero value. Measurement can operate for single measurement or continuous measurement. The Measurement Option block will define the operation mode. The graph selection will view the relation between the harmonics in a bar format. The print box is used to obtain a hard copy of the measurement result. Figure 8-10 shows the current harmonic measurement screen. Refer to Section 8.6.5 for current measurement range change if range change is required.

8.6.4.4 Voltage Harmonic Measurement

This screen will measure the fundamental and all the harmonics up to the 49th harmonics of the voltage waveform for the selected phase in volts and compute the percentage of harmonics to the fundamental. Measurement result will not be viewed if the fundamental is at zero value. Measurement can operate for single measurement or continuous measurement. The Measurement Option Block will define the operation mode. The graph selection will view the relation between the harmonics in a bar format. The Print box is used to obtain a hard copy of the measurement result. Figure 8-11 shows the Voltage Harmonic Measurement screen.

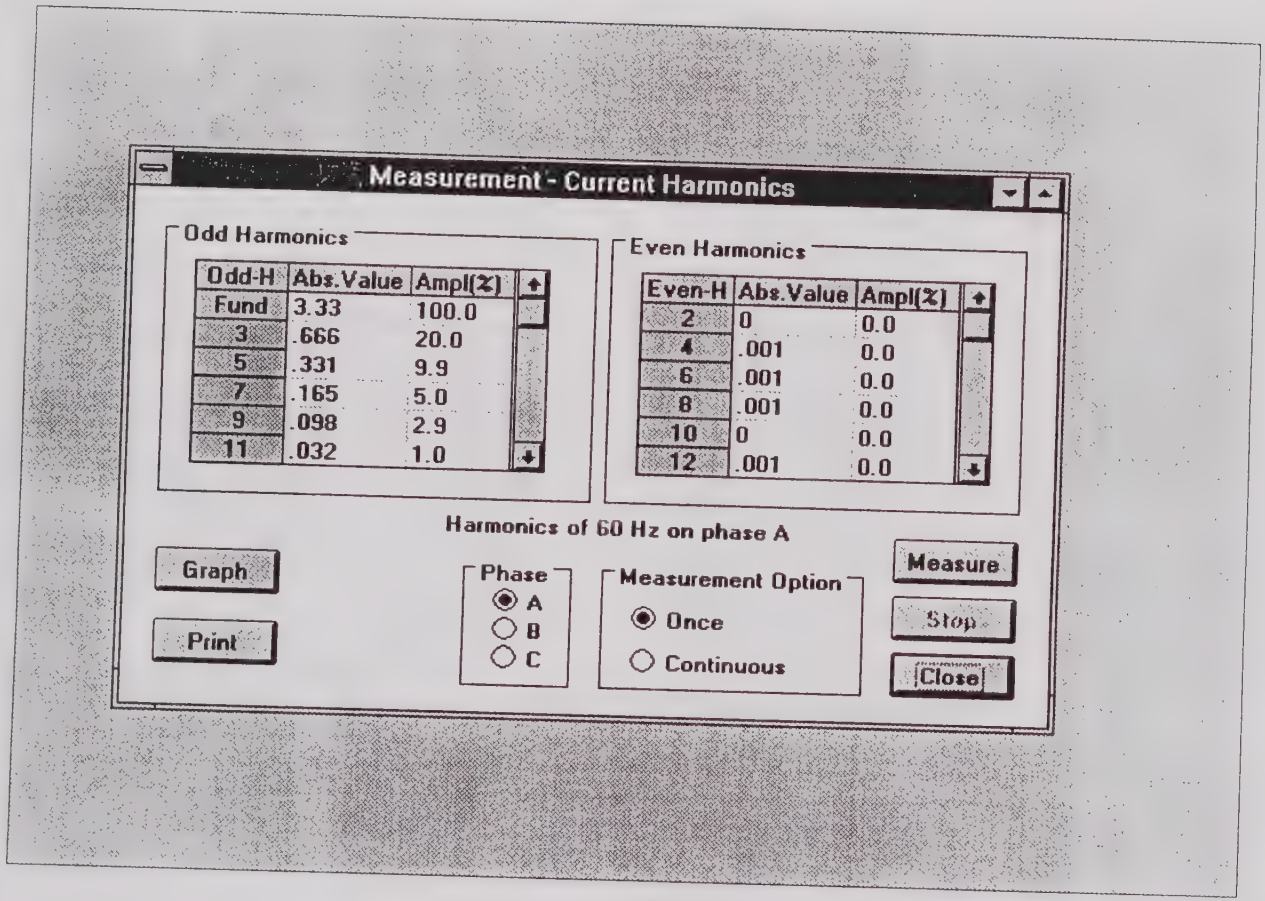

Measurement - Current Harmonics
Odd Harmonics
Odd-H | Abs.Value | Ampl(%)
Fund | 3.33 | 100.0
3 | .666 | 20.0
5 | .331 | 9.9
7 | .165 | 5.0
9 | .098 | 2.9
11 | .032 | 1.0
Even Harmonics
Even-H | Abs.Value | Ampl(%)
2 | 0 | 0.0
4 | .001 | 0.0
6 | .001 | 0.0
8 | .001 | 0.0
10 | 0 | 0.0
12 | .001 | 0.0
Harmonics of 60 Hz on phase A
Graph
Print
Phase
A
B
C
Measurement Option
Once
Continuous
Measure
Stop
Close

Figure 8 - 10

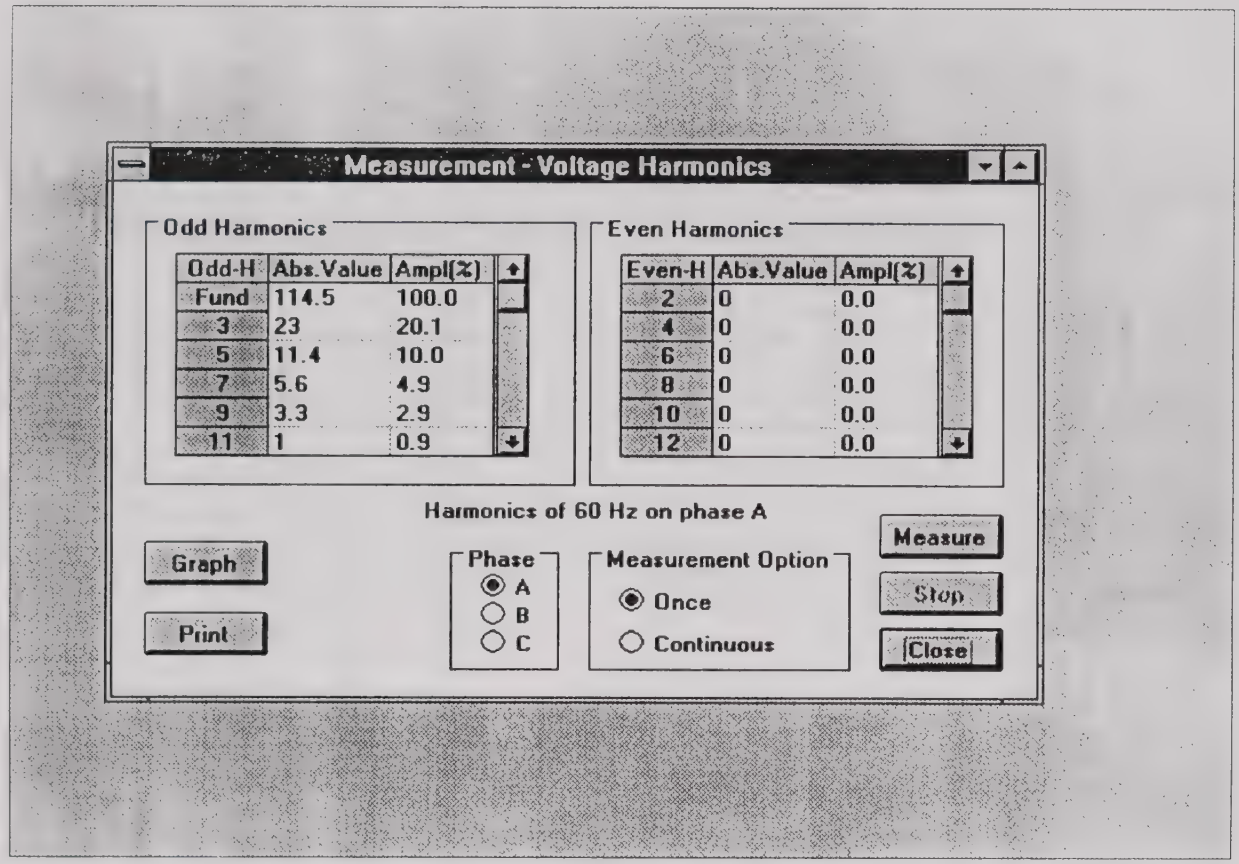

Measurement - Voltage Harmonics
Odd Harmonics
Odd-H
Abs.Value
Ampl(%)
Fund 114.5 100.0
3 23 20.1
5 11.4 10.0
7 5.6 4.9
9 3.3 2.9
11 1 0.9
Even Harmonics
Even-H
Abs.Value
Ampl(%)
2 0 0.0
4 0 0.0
6 0 0.0
8 0 0.0
10 0 0.0
12 0 0.0
Harmonics of 60 Hz on phase A
Graph
Print
Phase
A
B
C
Measurement Option
Once
Continuous
Measure
Stop
Close

Figure 8 - 11

8.6.5 INTERFACE SETUP SCREEN

This screen defines the RS232 configuration and GPIB address selection. The command line block allows entry of any SCPI and Dot 2 command that is supported by the HGA. The response for query command will be displayed in the response box. Click on SEND is required to send the command. Figure 8-12 shows the Interface screen.

Certain functions are not controlled by the HGA and must be entered from the command line in SCPI format. The following are some of the commands that must be used.

8.6.5.1 Current Measurement Range Change

To change the current range for measurement enter the following command:

MEAS:CURR:RANG<sp><NRf>

where <sp> is a required space and <NRf> is the range data. There are 4 current ranges for the standard HGA configuration. The 2, 4, 8 and 16 amps. The HGA auto ranges between the 2 amps and the 4 amps. It also auto ranges change between the 8 amps and 16 amps. It is required to use the above command to change range between the 4 amps and the 8 amps. All loads must be removed to change the current between the 4 amps and the 8 amps ranges. To find the current range for the current measurement use the following command.

MEAS:CURR:RANG?

8.6.5.2 External Sync

To synchronize the phase A output to an external sync input, the following command must be used.

FREQ:MODE<sp>SENS

where <sp> is a required space. The external sync input must be a valid TTL signal with the proper frequency connected to the proper input to the HGA Interface. Failure to do so will result in a very distorted output that could damage the power source.

To define find the frequency mode use the following query command.

FREQ:MODE?

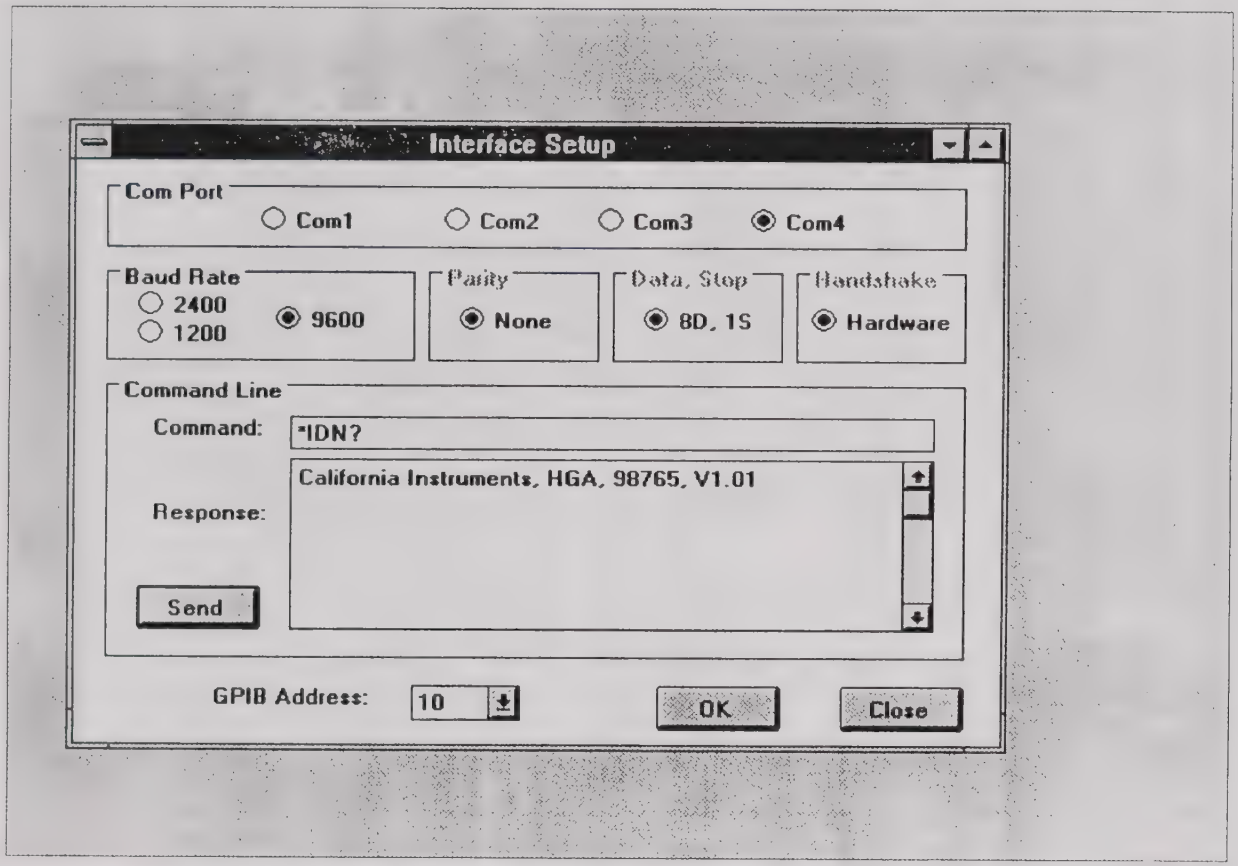

Interface Setup
Com Port
Com1
Com2
Com3
Com4
Baud Rate
2400
1200
9600
Parity
None
Data, Stop
8D, 1S
Handshake
Hardware
Command Line
Command:
*IDN?
Response:
California Instruments, HGA, 98765, V1.01
Send
GPIB Address:
10
OK
Close

Figure 8 - 12

8.6.5.3 Common Command

Some of the following common commands are useful to find information about the HGA status.

*IDN?	This query will return the serial number and the firmware revision.
*ESR?	This query will return the value of the standard event register.
*OPT?	This query will return the HGA configuration option of the GUI.

Refer to Section 5 for complete SCPI reference command descriptions.

8.6.5.4 Fault Source

If the HGA detects a fault condition, the output voltage will remain at zero voltage. To find the source of the fault the following command is used:

FAULT:SOURCE?

A response for any value other than zero will inhibit the output voltage programming. Refer to paragraph 5.9 for a description of all faults.

8.6.6 HARMONIC GENERATION SCREEN

This screen will be used to generate a waveform by defining the harmonic content as a percentage of the fundamental and relative phase angle. Harmonic data is entered using the numeric window entry and the ENTER button. The CLEAR button is used to clear a data entry. The SAVE button is used to save a waveform table to a floppy or a hard disk. The load button is used to load a known waveform from a floppy or a hard disk to a waveform table. The Compute button will generate the data points for the waveform and will display the shape of the waveform in the graph area in the lower left corner of the screen. Waveform number must be selected in the Destination block by clicking on the down arrow and selecting the waveform number. The Send Button will transmit the waveform to the HGA. To output the waveform, custom waveform is selected from the Steady State screen and the waveform is selected for each phase in the window under custom. Figure 8-13 shows the Harmonic Generation screen.

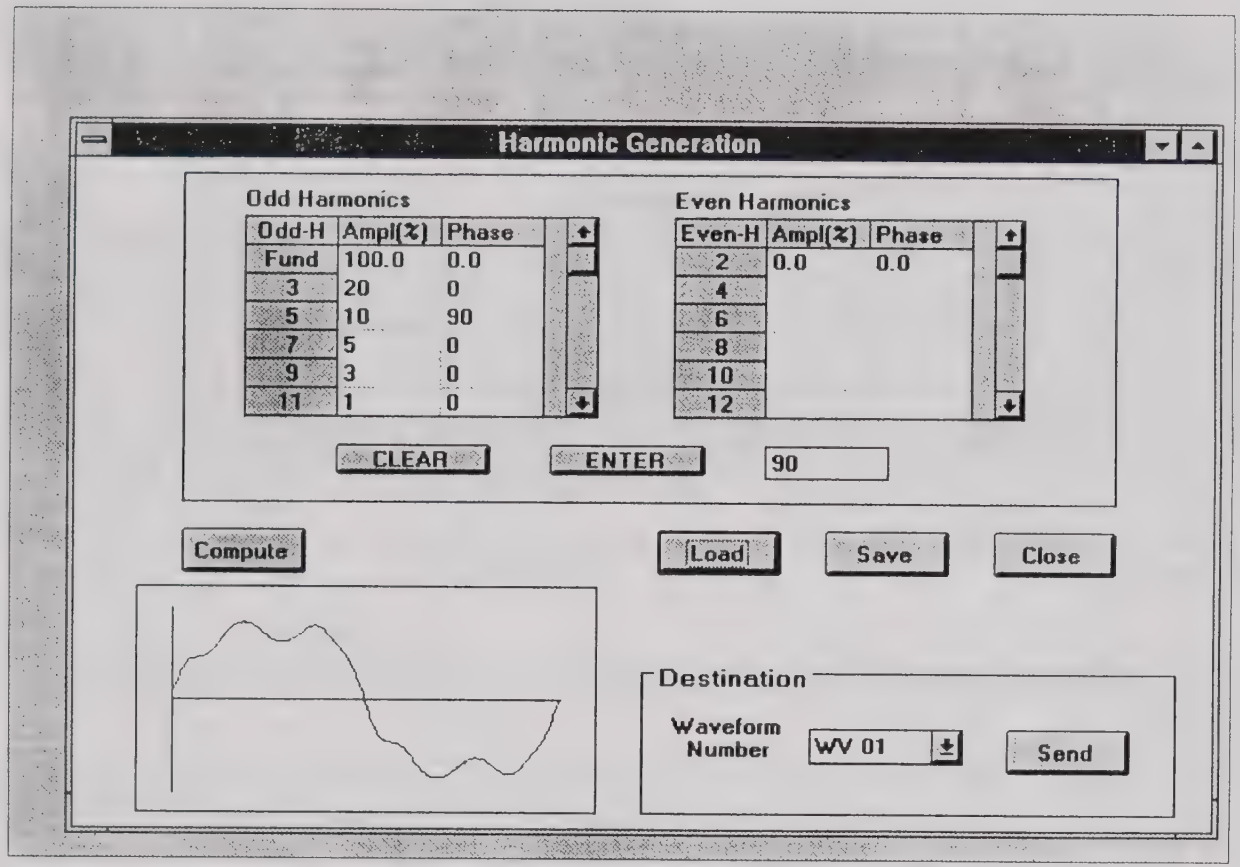
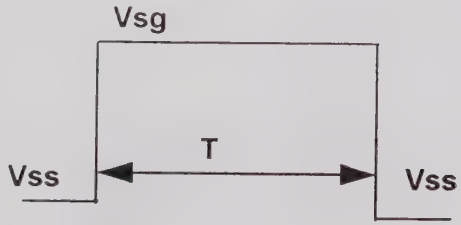

Harmonic Generation
Odd Harmonics
Odd-H
Ampl(%)
Phase
Fund
100.0
0.0
3
20
0
5
10
90
7
5
0
9
3
0
11
1
0
Even Harmonics
Even-H
Ampl(%)
Phase
2
0.0
0.0
4
6
8
10
12
CLEAR
ENTER
90
Compute
Load
Save
Close
Destination
Waveform Number
WV 01
Send

Figure 8 - 13

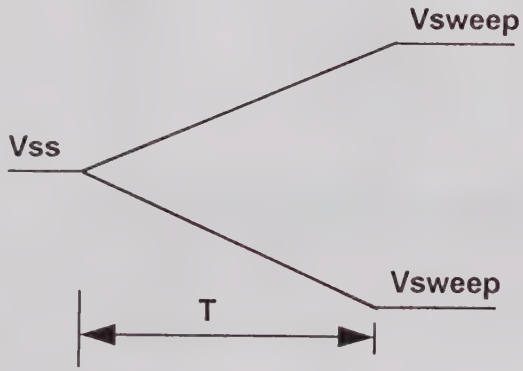
Delay

Vsrg/sag



Vdrop

Vsweep

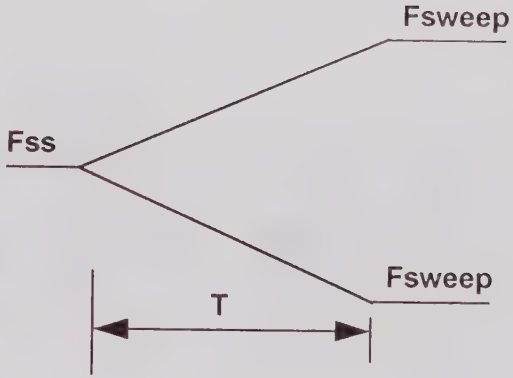


ss-Steady state

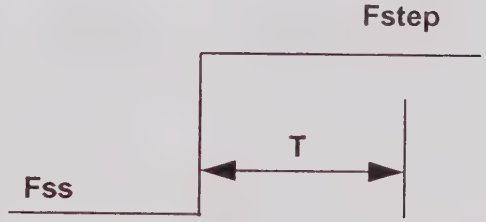
Tmin - 2msec

Vstep

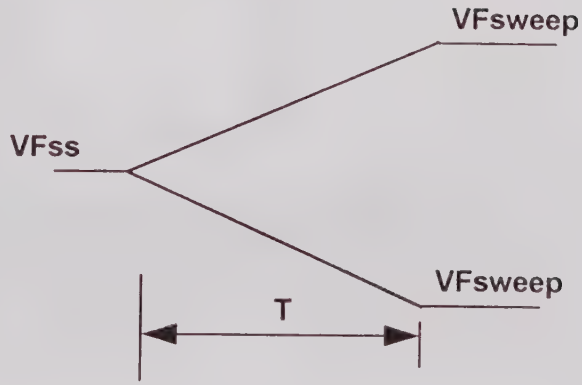
Fsweep



Fstep



VFsweep



Transient
Figure 8-14

Appendix A

Number	Vendor Name	City	State
2000A	Electricord	Westfield	PA
2000C	Jackson Bros.	Weadon,Surrey	GB
2000S*285641	SPCOA - Refac Elect Corp	Winsted	CT
2000W	Hilton Roos Co	Southampton	PA
20001(527455)	Tieco	Los Angeles	CA
200AC	Itec	Santa Clara	CA
200AD(55112)	Plessey (Westlake Cap. Inc.)	Westlake Village	CA
200AG	LaFrance	Philadelphia	PA
200AH(54363)	Jan Crystal	Ft. Myers	CA
200AL(53495)	Daze Components, Inc.	Gardena	CA
200AM	Kraus & Naimer	Santa Monica	CA
200AM	Ritz Instrument Transformer	Redondo Beach	CA
200AS	Switches Incorporated	Mt. View	CA
200AT(62643)	United Chemi-Con	Rosemont	IL
200AU	JMJ Technical Prod. Inc.	Kendall Park	NJ
200AV(61813)	Semi Processes, Inc.	San Jose	CA
200AW	Hirose	Chatsworth	CA
200AZ(63078)	Aperonics	Mentor	OH
200AT	Silicon Power Cube Corp.	Long Beach	CA
200BA(61271)	Pulsitron	Santa Clara	CA
200BA(61964)	Omron Electronics, Inc.	Schaumburg	IL
200BB	Hallmark Metals, Inc.	Glendora	CA
200BC	Toshiba America, Inc.	Tustin	CA
200BD(55982)	Electronic Essentials	Woodside	NY
200BE(57858)	Kel-Am	Elden	MO
200BF(55285)	Berquist	Minneapolis	MN
200BG	Panasonic	Secaucus	NY
200BH	Century Components	Canyon Country	CA
200BI(54186)	Micro Power Systems	Santa Clara	CA
200BJ(06776)	Robinson Nugent	New Albany	IN
200BL(13150)	Beau Products (Vernitron)	Laconia	NH
200BM(91725)	Coreolinger (Gerrard AJ & Co.)	Des Plaines	IL
200BQ	Mitsubishi Electronics Amer.	Sunnyvale	CA
200BP	Silicon Power Cube	Long Beach	CA
200BR	Secme	Bagnolet	France
200BS	Panel Components Corp.	Santa Rosa	CA
200BT	Metal-Cal Div., Avery Prod.	Inglewood	CA
20079	AMP Inc.	Harrisburg	PA
20851	Sangamo Electronic Co.	Pickens	SC
20866	Goe Eng. Co., Inc.	City of Industry	CA
21002	G.E. Co., Ind. & Pwr. Cap. Dept.	John St. dudson Falls	NY
01121	Allen-Bradley Co.	Milwaukee	WI
01139	G.E. Co., Silicone Prod.	Waterford	NY
01295	Texas Instruments	Dallas	TX
01961	Pulse Engineering, Inc.	San Diego	CA
02111	Spectrol Electronics	City of Industry	CA
02113	Coilcraft, Inc.	Cary	IL
02335	Fairchild Controls Corp.	Hicksville,LI	NY
02375	American Insulating Mach. Co.	Philadelphia	PA
02538	Texas Electronics Co.	Dallas	TX
02660	Amphenol Corporation	Broadview	IL
02768	Illinois Tool Works, Inc.	Des Plains	IL
02799	Dae Code 172136		
03507	General Electric Company	Syracuse	NY
03508	General Electric Company	Syracuse	NY
03797	Eldema Corporation	Compton	CA
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls	NJ
03911	Claitex Corporation	New York	NY
04009	Arrow-Hart and Hegeman Elec.	Hartford	CT
04099	Capcoj, Inc.	Grand Junction	CO
04713	Motorola Semiconductor Prod.	Phoenix	AZ
04729	Universal Components Corp.	Green Brook	NJ
04963	3-M	St. Paul	MN
05245	Corcom Inc.	Chicago	IL
05276	Pomona Electronics., Inc.	Pomona	CA
05397	Kemet, Union Carbide Corp.	Cleveland	OH
05791	Lyn-Tron, Inc.	Burbank	CA
05820	Wakefield Engineering, Inc.	Wakefield	MA
05972	Loctite Corp.	Newington	CT
06383	Pandait Corp.	Tinley Park	IL
06314	Stantron, Wyce Metal Prod.	N. Hollywood	CA
06540	Amatom Elect. Hardware	New Rochelle	NY
06665	Precision Monolithics Inc.	Santa Clara	CA
06776	Robinson Nugent, Inc.	New Albany	IN
06915	Richco Plastics, Co.	Chicago	IL
07008	Kalvin Electric Company	Van Nuys	CA
07263	Fairchild Camera & Instr.	Mt. View	CA
07387	Birtcher Corporation	Los Angeles	CA
07556	Omitrack Calabro Plastics	Upper Darby	PA
07633	Epoxy Prod. Co., Allied Prod. Corp.	New Haven	CT
07707	USM Corp. (USM Fastener Div)	Shelton	CT
07716	IRC Incorporated	Burrington	IA
07910	Dae Code 413818		
08028	Loctite (Auto & Consumer Grp)	Palo Alto	CA
08057	Spang Ind. (Magnetics Div)	Sandy Lake	PA
08065	Accurate Rubber and Plastics	San Diego	CA
08261	Spectra Strip (Amphenol)	Garden Grove	
08289	Allan Daibert Co.	Pomona	CA
08353	Brisrol Co. of Canada	Toronto, Ont	Canada
08730	Darby & Barton (Vemaline Prod. Div.)	Warwick	RI
08779	Signal Transformer	Brooklyn	NY
09214	GE (Semiconductor Prod. Div)	Auburn	NY
09353	C & K Components	Newton	MA
09922	Burndy Corp.	Norwalk	CT
10389	Chicago Switch	Chicago	IL
.1815	Cherry/Textron (Fastener Div)	Santa Ana	CA
.2406	Elpac Electronics	Santa Ana	CA
.2697	Clarostat Mfg.	Dover	NH
.3103	Thermalloy Company	Dallas	TX
.3350	Vernitron Corp (Bees Prod.)	Laconia	NH
.3604	Sperry Corp. Elec. Systems	Great Neck	NY
.3919	Burr-Brown	Tucson	AZ
.4099	Semtech Corporation	Newbury Park	CA
.4604	Elmwood Sensors Inc.	Cranston	RI
.4635	Cornell-Dubilier Elect. Corp.	Newark	NJ
.4726	Rollinswerth Co.	Phoenixville	PA
.4752	Electra Screw, Inc.	San Gabriel	CA
.4908	Electronic Instrument and Specialty Corp.	Stoneham	MA
.5238	ITT Semiconductors	Lawrence	MA
.5454	Ametek EMI (Boden Div)	Anaheim	CA
.5636	Electrocel	Norteridge	CA
.5801	Fenwell Electronics	Framingham	MA
.5818	Amelco Teledyne, Inc.	Mt. View	CA
.5912	Ameley	Los Angeles	CA
.6067	California Instruments Co.	San Diego	CA
.6750	Delco Radio Div., Gen. Mtrs.	Kokomo	IN
.6956	Deanicom	Framingham	MS
17856	Silicomix, Inc.	Santa Clara	CA
18076	Omnco	City of Industry	CA
18178	Vactec, Inc.	Maryland Heights	MO
.8310	Concord Electronics Corp.	New York	NY
.8324	Signetics	Sunnyvale	CA
.8612	Vishay Instruments, Inc.	Malvern	PA
.8677	Scanbe Mfg. Co. (Ecco Corp.)	Monterey Park	CA
.8722	RCA	Mountaintop	PA
.8726	Voltronics Corp.	Hanover	NJ
.9080	Bomtech Company	Hawthorne	CA
.9404	Buckeye Stamping Company	Columbus	OH
.9845	Solitron Devices (Semi-conductor Group)	Riviera Beach	FL
20599	Elastic Stop Nut Corp.	Van Nuys	CA
20850	Product Components Corp.	Hastings-on-Hudson	NY
20916	Pomeron, Inc.	San Francisco	CA
21011	ECC	Burlington	MA
24355	Analog Devices, Inc.	Norwood	MA
24446	General Semiconductor Inc.	Tempe	AZ
24746	Facelco, Inc.	Paramount	CA
24931	Specialty Connector Co., Inc.	Greenwood	IN
24972	AEG-Telefunken Corp.	Summerville	NJ
25401	Amperex Electronic Corp.	Slatersville	RI
25497	Meter Master	Los Angeles	CA
26405	Marathon Electric Mfg. Corp.	Bowling Green	OH
26806	American Sattler, Inc.	Costa Mesa	CA
27014	National Semi-Conductor Crp.	Santa Clara	CA
27191	Cutler-Hammer, Inc	Milwaukee	WI
27264	Molex	Downers Grove	IL
27335	B & B Motor & Control Corp.	New York	NY
27556	IMB Electronic Products	Santa Fe Springs	CA
27603	Varo, Inc	St. Garland	TX
27735	F-Dyne Electronics	Bridgeport	CT
27832	Tyanee Aircraft	Newport Beach	CA
28480	Hewlett-Packard Co.	Palo Alto	CA
28520	Heyman Mfg. Company (Heycal	Kenilworth	NJ
28606	Schiln Ltd.	Rexdale Ont.	Canada
29177	Raymond Inc. (Tridair Ind.	Torrance	CA
29581	Bussco Eng., Inc.	El Segundo	CA
30019	International Components Crp.	Asbury Park	NJ
30161	Mavid Engineering, Inc.	Lacomia	NH
30897	Darann Company	Sylmar	CA
30980	Electra/Midland (Mepcor Electra)	San Diego	CA
31827	Budvig Mfg. Co.	Ramona	CA
31951	Tricidge, Inc.	Pittsburg	PA
32293	Intersil	Cupertino	CA
32559	Bivar, Inc.	Santa Ana	CA
32997	Bourns Inc. (Trimpot Div)	Riverside	CA
33005	Jewell Electrical Inst. Inc.	Manchester	NH
33335	Logic Dynamics, Inc.	Gardena	CA
33716	Klingebacher, Murray Co.	Los Angeles	CA
33855	Ducommun, Inc.	Los Angeles	CA
33901	Caliber Corp.	Irvington	NJ
34238	Mills Resistor Co.	Los Alamitos	CA
34333	Silicon General	Westminster	CA
34649	Intel Corporation	Santa Clara	CA
35007	Aerovox Canada Ltd.	Amherst NS	Canada
37964	Linear Technology, Inc.	Burlington, Onc	CAN
44655	Ohmite Manufacturing Co.	Skokie	IL
45722	Parker-Kalon	Clifton	NJ
46384	Penn. Eng. and Mfg. Corp.	Doylestown	PA
50157	Midwest Components, Inc.	Muskegon	MI
50522	Monsanto, Electronic Special Products	Cupertino	CA
50558	Electronic Concepts, Inc.	Eatontown	NJ
50811	Rousec Corp.	Santee	CA
51167	Acies Electronics, Inc.	Frenchtown	NJ
51506	Accurate Screw Machine Co.	Hutley	NJ
51705	ICO/Rally	Palo Alto	CA
52072	Circuit Assembly Corp.	Costa Mesa	CA
52745	Timco	Los Angeles	CA
53076	Cinrex, Inc.	Buffalo	NY
53495	Data Components, Inc.	Gardena	CA
54361	Edwards Sheet Metal Works	Fredericktown	OH
54407	Power-One Co.	Camarillo	CA
55322	Sametr, Inc.	New Albany	NY
55566	RAF Electronic Hardware, Inc.	Seymour	CT
56289	Sprague Electric Company	North Adams	MA
56637	RCD Components, Inc.	Manchester	NH
57640	United Chem-Con Corp.	Philadelphia	PA
57856	Kel-Am, Inc.	Elden	MO
58474	Superior Electric Company	Bristol	CT
59730	Thomas and Betts Company	Elizabeth	NJ
59993	International Rectifier Semiconductor Div.	El Segundo	CA
60395	Elcar, Inc.	Milditas	CA
61394	Seeq Technology, Inc.	San Jose	CA
61441	Saronix	Palo Alto	CA
61529	Aromat Corp.	Mountainside	NJ
61735	Pulse Engineering, Inc.	College Park	MD
62483	Omnitron Corp. of America	Torrance	CA
62643	United Chemicon, Inc.	Rosemont	IL
62786	Mitechi America Ltd.	San Jose	CA
63743	Ward Leonard Electric Co.	Mt. Vernon	NY
63791	Star Micronics, Inc.	New York	NY
70318	Allmetal Screw Prod. Co.	Garden City	NY
70903	Belden Manufacturing Co.	Chicago	IL
71218	Bud Industries, Inc.	Willoughby	OH
71279	Cambridge Thermionic Corp.	Cambridge	MA
71400	Bussmann Mfg. Div. McGraw-Edison Co.	St. Louis	MO
71450	CTS Corporation	Elkhart	IN
71468	ITT Cannon Electric, Inc.	Los Angeles	CA
71590	Centralab Div. Globe-Union	Milwaukee	WI
71707	Coto-Coil	Providence	RI
71744	Chicago Miniature Lampworks	Chicago	IL
71785	Cinch Manufacturing Company	Chicago	IL
71984	Dow Corning Corp.	Midland	MI
72136	Elmenco (Electro Motive)	Willimantic	CT
72619	Dialight Corporation	Brooklyn	NY
72699	General Instruments	Newark	NJ
72982	Erie Technological Prod. Inc.	Erie	PA
73138	Beckman Instruments, Inc.	Fullerton	CA
73612	Consolidated Electronic Wire and Cable Corp.	Chicago	IL
73734	Federal Screw Products, Inc.	Chicago	IL
74193	Heinemann Electric Company	Trenton	NJ
74545	Harvey Hubbell, Inc.	Bridgeport	CT
74840	Illinois Condenser Co.	Chicago	IL
74970	E.F. Johnson Company	Waseca	MN
75042	IRC Electronic Components	Philadelphia	PA
75382	Kulka Electric Corporation	Mt. Vernon	NY
75582	Laviton Mfg. Co.	Little Rock	NY
75915	Littelfuse, Inc.	Des Plaines	IL
76385	Minor Rubber Co., Inc.	Bloomfield	NJ
77068	Pabst Eng. Equipment Co.	Elizabeth	NJ
77132	United-Carr Inc., Potvin Div	Waterbury	CT
77342	Potter and Bluefield Div, AMP	E. Princeton	IN
78189	Shakeproof Div. IL Tool Works	Chicago	IL
78553	Tinnerman Products, Inc.	Cleveland	OH
79136	Johns-Manville Products Corp	Chicago	IL
79136	Walden Rominoor Inc.	Long Island City	NY
79963	Zierick Mfg. Corp.	New Rochelle	NY
80031	Mepco/Electra	Morristown	NJ
80223	United Transformer Co.	New York	NY
80294	Bourns, Inc.	Riverside	CA
80495	High Voltage Engineering Corp (Anderson Pwr Prod. Div)	Brigston	MA
81095	Triad Transformer Corp.	Venice	CA
81312	Winchester Electronics	Oakville	CT
81348	(Fed. Specs) Promulgated by General Services Administration Washington DC		
81349	Military Specification or Commercial Generic Number		
81541	Airpax Corp.	Cambridge	MD
81603	Race Products Co.	Chicago	IL
81851	Bentley-Harris Mfg Co.	Lionville	PA
82142	Standard Grigsby	Aurora	IL
82189	Switchcraft, Inc.	Chicago	IL
82877	Rotron Mfg. Co., Inc.	Woodstock	NY
82893	Vector Electronics, Inc.	Sylmar	CA
83330	Herman H. Smith, Inc.	Brooklyn	NY
83486	Dice Tool & Screw Corp.	Rockford	IL
83640	Brady W.H. Co.	Milwaukee	WI
86684	RCA	Harrison	NJ
86928	Seastrom Mfg. Co., Inc.	Glendale	CA
87034	Marco-Oak Industries	Anaheim	CA
88245	Dearo Div., Litton Ind.	Van Nuys	CA
90201	Mallory Capacitor Co.	Indianapolis	IN
91506	Augat, Inc.	Attleboro	MA
91637	Dale Electronics, Inc.	Columbus	NE
91662	Elco Corporation	Willow Grove	PA
91802	Industrial Devices, Inc.	Edgewater	NJ
91833	Keystone Electronics Corp.	New York	NY
91947	National Tel-Tronics	Readville	PA
92194	Alpha Wire Corp.	Elizabeth	NJ
93303	Pentagon Products Co.	Washington	DC
94222	Soucnco, Inc.	Lester	PA
94696	Magnecraft Electric Co.	Chicago	IL
95146	Alco Electronic Prod., Inc.	No. Andover	MA
95303	RCA	Cincinnati	OH
95354	Methode Manufacturing Corp.	Rolling Meadows	IL
95366	Arnold Engineering Co.	Marengo	IL
95967	Wectessor Company, Inc.	Chicago	IL
96906	Military Std		
97515	Electronic Engineering Co.	Santa Ana	CA
98159	Rubber Tech, Inc.	Gardena	CA
98291	Sealetc Corp.	Mamaroneck	NY
98376	Ilco Mfg. Co (West)	Burbank	CA
98978	IEMC	Burbank	CA
99017	Protective Closures Co., Inc. (Caplugs Div)	Buffalo	NY
99217	Bell Industries, Inc.	Delavan	WI
99742	Permacell	New Brunswick	NJ
99743	IMC	Raymond	CA
99800	Delevan Electronics Corp.	Aurora	NY

ONE YEAR WARRANTY

CALIFORNIA INSTRUMENTS CORPORATION warrants each instrument manufactured by them to be free from defects in material and workmanship for a period of one year from the date of shipment to the original purchaser. Excepted from this warranty are tubes, fuses, and batteries which carry the warranty of their original manufacturer where applicable. CALIFORNIA INSTRUMENTS will service, replace, or adjust any defective part or parts, free of charge, when the instrument is returned freight prepaid, and when examination reveals that the fault has not occurred because of misuse, abnormal conditions of operation, user modification, or attempted user repair. Equipment repaired beyond the effective date of warranty or when abnormal usage has occurred will be charged at applicable rates. CALIFORNIA INSTRUMENTS will submit an estimate for such charges before commencing repair, if so requested.

PROCEDURE FOR SERVICE

If a fault develops, notify CALIFORNIA INSTRUMENTS or its local representative, giving full details of the difficulty, including the model number and serial number. On receipt of this information, service information or a Return Material Authorization (RMA) number will be given. Add RMA No. to shipping label. Pack instrument carefully to prevent transportation damage, affix label to shipping container, and ship freight prepaid to the factory. CALIFORNIA INSTRUMENTS shall not be responsible for repair of damage due to improper handling or packing. Instruments returned without RMA No., or freight collect will be refused. Instruments repaired under Warranty will be returned by prepaid surface freight. Instruments repaired outside the Warranty period will be returned freight collect, F.O.B. CALIFORNIA INSTRUMENTS, San Diego, CA. If requested, an estimate of repair charges will be made before work begins on repairs not covered by the Warranty.

DAMAGE IN TRANSIT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed immediately with the carrier. A full report of the damage should be obtained by the claim agent, and a copy of this report should be forwarded to us. CALIFORNIA INSTRUMENTS will prepare an estimate of repair cost and repair the instrument when authorized by the claim agent. Please include model number and serial number when referring to the instrument.

HGA Graphical User Interface
Training manual

California Instruments

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1. Introduction

The California Instruments Harmonic Generator / Analysis System is a powerful controller for AC power sources, capable of generating a wide variety of waveforms. At the same time, it is capable of measuring voltage and current harmonics up to the 50th harmonic. To facilitate the creation of harmonic waveforms, a Windows 3.1™ compatible Graphical User Interface program is supplied with the HGA.

This training manual takes the first time user through all the functions and operations of the GUI software. To successfully work through this manual, some basic knowledge about the operation of the Windows operating environment and the use of a mouse is required. If you are not familiar with either, we suggest you work through the Windows Tutorial first which is located in the Help menu of the Windows Program Manager.

Note that this appendix covers the operation of the GUI software only. It is strongly recommended that you familiarize yourself with the operation of the power source driven by the HGA as well. This is best done by studying the instruction manual preceeding this appendix.

2. Requirements

To complete the exercises covered by this training manual, you will need the following equipment :

- HGA Controller with AC power source. (L Series, T Series or FCS Series)
- PC capable of running windows
- IEEE interface Card or free RS232C serial port in the PC
- IEEE Cable (not supplied with HGA) or RS232C cable supplied with HGA
- Single or Three phase load, depending on the AC source configuration
- Oscilloscope with two or more channels.

If any of these items is missing, you will not be able to perform all the tasks this training manual covers. You may still benefit from working through this material however as many setup procedures can still be accomplished even without an HGA connected. In the latter case, obtain a copy of the HGA GUI demo software which will run on a Windows PC without a HGA. Measurements in this case will be simulated and will not correspond to the ones shown in this training manual.

3. Setup and Installation

This section covers installation of the HGA GUI from the distribution disk to the user's PC. Make sure the PC is capable of running Windows 3.1™ Enhanced mode with at least 4 Mbyte of memory and 2 Mbyte of available hard disk space.

3.1 Verify front panel operation

Prior to connecting the HGA to the PC, make sure it is connected to the AC power source by following the instructions in the instruction manual for the HGA. Different power source configurations will require different connections to be made. The output of the AC source is routed through the HGA to allow it to make the necessary measurements. Turn on the HGA and verify correct operation of the HGA and the AC power source by operating it manually from the front panel. While most capabilities of the HGA cannot be controlled from the front panel, it can be used to set output voltage, frequency and current limit. Do not proceed with this training course unless the HGA operates correctly from the front panel.

3.2 Connecting the HGA to the PC

Determine the type of interface that will be used to connect the HGA to the PC. If RS232C serial communication will be used, connect the 9 pin to 9 pin serial cable. Note that this cable is marked for the PC side and the HGA side. Make sure the cable is oriented properly or it will not work. If the PC used has a 25 pin D connector port, use a 25 pin to 9 pin adapter. (Not supplied with the HGA). If you have difficulties operating over the serial interface, consult California Instruments Application Note #107 "Using the HGA Controller over the RS232C Interface".

If the PC is equipped with a National Instruments IEEE-488 bus controller card or compatible device, use of the IEEE-488 bus is preferred as it will provide better performance. In this case, a IEEE-488 cable is needed to connect the HGA to the PC. Make sure you screw down the IEEE connectors securely or they will not make good contact.

3.3 Installing the HGA GUI software

The HGA GUI software is distributed on a 3.5 inch high density diskette. The GUI must be installed from this diskette as all required files are compressed. You cannot copy the contents of this disk to your PC hard drive and run it. To install the HGA GUI, proceed as follows :

1. Turn on the PC and boot up in Windows 3.1™.
2. Insert the HGA GUI disk in drive A or B. If you do not have a 3.5 inch drive on the PC, you can copy the contents of the disk to a 5.25 inch diskette on a PC that is equipped with both drive types.
3. From the Program Manager, select the "File" Menu.
4. From the File Menu, select "Run..."
5. At the prompt, type "A:SETUP" or "B:SETUP" depending on the drive designator of the drive in which you inserted the disk.

The setup program will first ask you for the destination directory on the hard disk where you want the HGA GUI installed. The default directory is C:\HGA

6. Press "Continue" if you want to accept the default. If you want the program to reside at a different location, type in the complete path name including hard disk drive letter and then press "Continue". If you want to abort the setup procedure, click on the "Exit Setup" button. A warning will appear indicating the setup did not complete successfully. Click on the "OK" button to acknowledge the warning. This will take you back to the Program Manager.
7. Wait for the installation program to complete. An icon for the HGA GUI and a program group will be created automatically.
8. Remove the diskette from the drive.

You are now ready to start using the HGA GUI software.

4. User Interface aspects

This section reviews the various user interface aspects of the HGA GUI program. It covers menus and mouse operation. Experienced Windows users can skip sections 4.3 and 4.4.

4.1 Starting the HGA GUI

Use the mouse to double click on the HGA icon (yellow lightbulb). If you are not comfortable double clicking with a mouse, you can also click on the icon once to select it, and then press the Enter key. The program will load and display a start-up screen. This is shown in figure 1. Press the Enter key to proceed to the main program window.

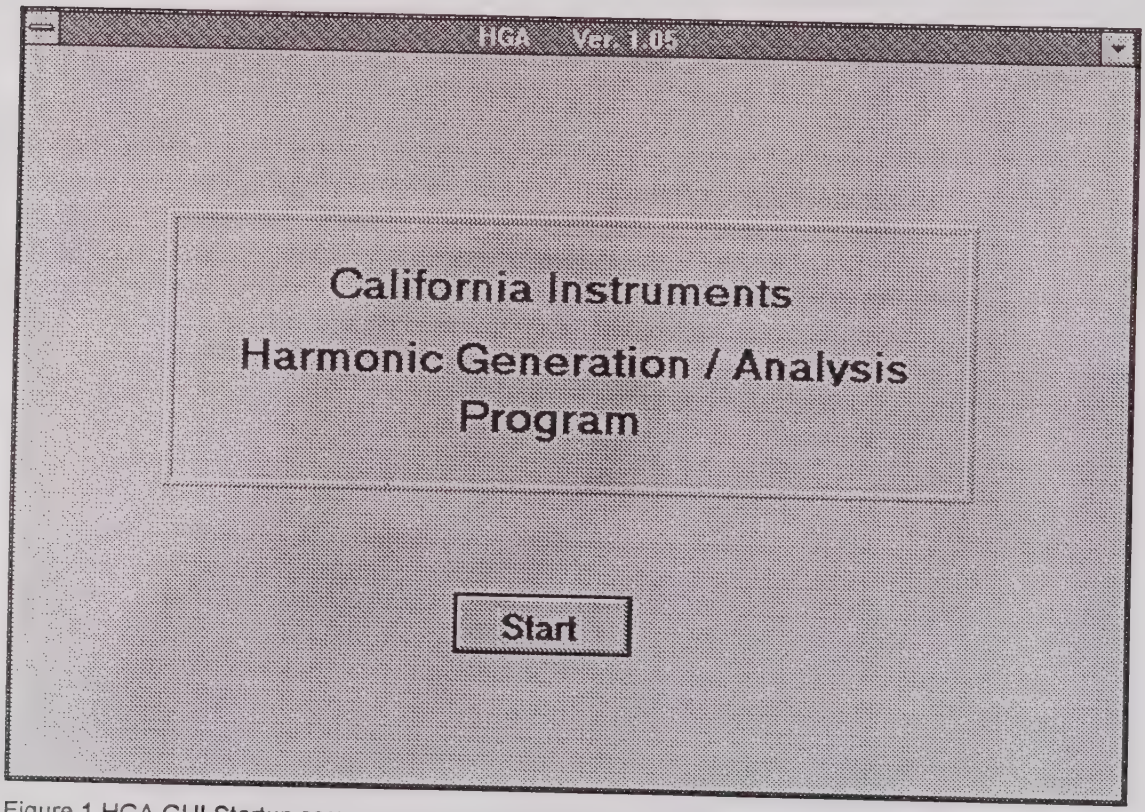


Figure 1 HGA GUI Startup screen

4.2 Main program window

The HGA GUI software is operated through a series of modal dialog boxes or screens that are all accessed from the main menu bar. The main menu bar is shown along the top edge of the main program window. The main program window only displays the type of interface used and the status of the IEEE-488 interface. Any IEEE-488 bus errors will be shown along the bottom of the main program window.

The various areas of the main program window are shown in figure 2. During the course of this training, you will be asked to select various menu items from time to time. This can be done in one of two ways :

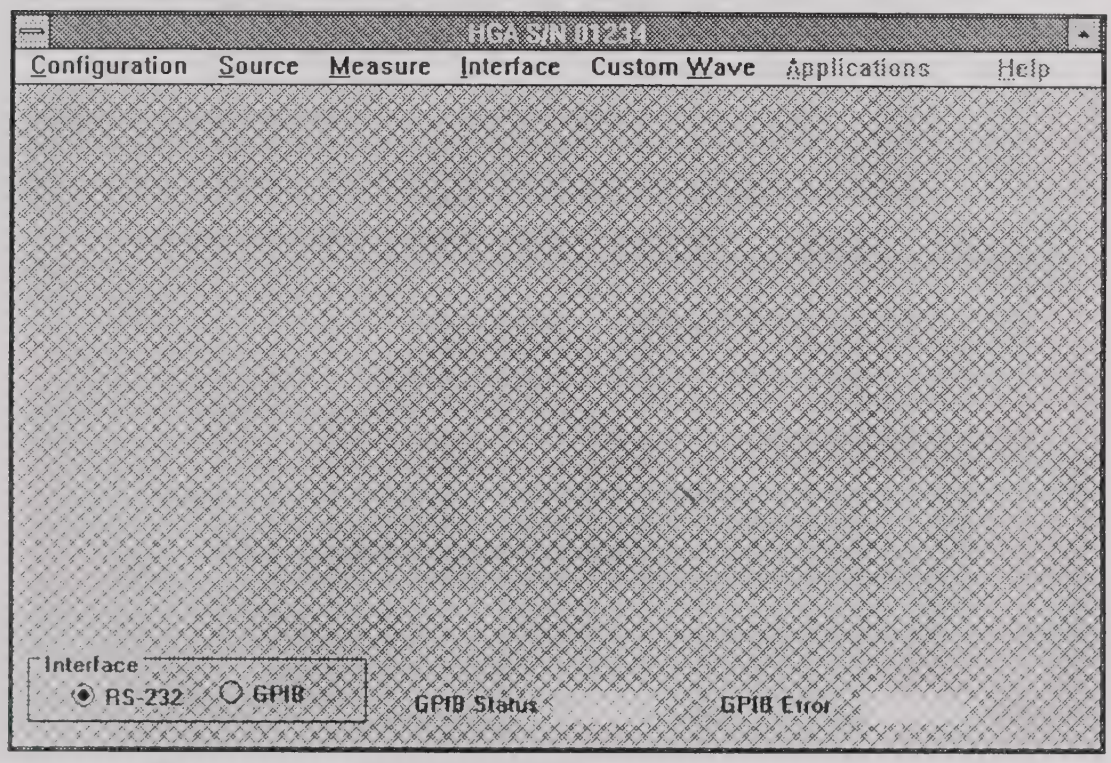


Figure 2 Main Program Window

4.3 Selecting menu items with the mouse

To select any menu item using the mouse, move the mouse pointer to the desired entry and press the left mouse button. (Click)

4.4 Selecting menu items from the keyboard

To select any menu using the keyboard, hold down the ALT key and press the letter of the menu item that is underlined. Thus, to select the "Interface" menu item, hold down the TAB key and press the letter "I".

Note that two menu items are currently not available and appear as light gray instead of black. They are "Applications" and "Help".

4.5 Switching between interfaces

At the bottom left of the main window is an "interface" box that allows you to toggle between RS232C and IEEE-488 operation. Under most conditions, this should not be required since there is no benefit to switching back and forth. If you do switch however, make sure both the RS232C and IEEE-488 cables are connected.

Figure 3 Switching between RS232C and IEEE-488

5. Command Line Interface Operation

The interface used by the HGA GUI is determined by the "config.dat" file located in the same directory as the HGA GUI executable. This is a binary file that is not accessible to the user. The information contained in this file is used by the HGA GUI at startup to determine the interface settings to use. It contains information on the Port to use - RS232C or IEEE-488, and parameters for each port. (baudrate and com port number for RS232, Address for IEEE-488).

The interface settings can be changed from the "Interface Setup" screen. This screen is accessed by selecting the **Interface** menu item.

1. Click on the Interface menu item to select the "Interface Setup" screen.
2. Verify that the interface selection shown matches the settings of the HGA. If not, select the correct interface type and parameters using the mouse.

This workbook was written around use of the RS232C serial interface on COM port 2 as is shown in figure 4.

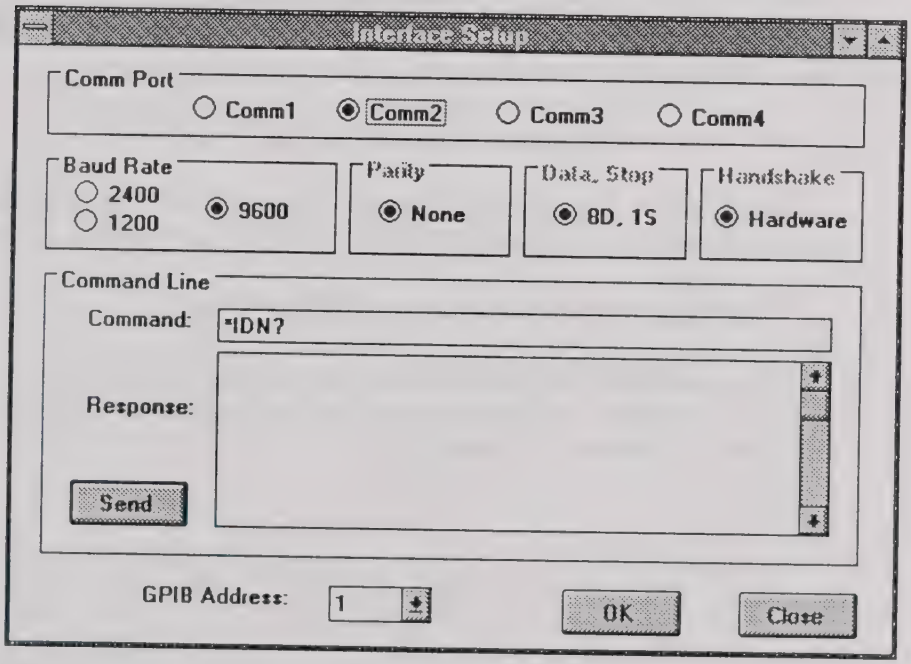


Figure 4 Interface Setup Screen

The Command line area located at the bottom of the Interface Setup screen acts as an interactive dialog mechanism between the PC and the HGA. Any valid command can be entered by the user in the Command box (editable field) and send to the HGA by clicking on the "Send" button. Responses to queries are shown in the Response box located directly below the Command line box. Care should be taken not to enter syntactically incorrect commands as no error checking is done on commands send by the user from the command line. When using this feature, refer to Chapter 5 of the HGA instruction manual.

5.1 Issuing Common Interface Commands

Under normal operation, the command line is not required to operate the HGA with the HGA GUI program. It is covered here only as an illustration of interacting with the HGA directly for special applications. We will issue some commonly used responses and observe the response.

5.1.1 Unit Identification command

The default command shown in the command line text box is always '*IDN?' which is the identity query. It is a useful command to check for the proper connection to the HGA.

1. Click on the Send button to issue the *IDN? command.

Since this is a query, a response is received from the HGA and shown in the response box. The unit will identify itself by sending the following string :

"California Instruments, HGA, 70805, V1.02"

The four fields show the company name, Model, Serial number and Firmware version. The firmware version may be different on your unit as firmware is updated from time to time.

5.1.2 Selftest Command

The selftest query command can be used to verify correct operation of the HGA. If the selftest passes, a zero is returned in response to the query. If a problem is found, a non-zero result is returned.

1. Select the Command line text box
2. Replace the default '*IDN?' command with '*TST?'
3. Click on the Send button

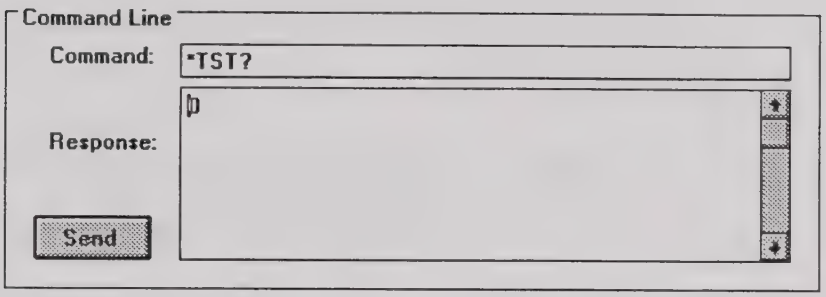


Figure 5 Selftest command

After a few seconds, the test result should appear in the Response window. If you obtain a non zero response, consult the factory.

5.1.3 Checking the Error Queue

Anytime an error occurs on the HGA, an error message is posted to the error message queue and one of four bits in the Event Status Register is set. The ESR bits can be used to generate a service request to the controller. If the error message queue is not read, it will eventually overflow. During normal operation of the HGA GUI program, the Error Queue is checked by the GUI program when needed. If you want to read the Error queue, you can do so from the command line.

1. Enter the 'SYSTEM:ERROR?' query command in the command text box
2. Click on the Send button

The response should be :

0,"No error"

3. Next, type an invalid command in the command text box such as 'XYZ'
4. Click on the Send button to send the invalid command
5. Now repeat steps 1 and 2 above to query the error message queue again.

The response should be:

-100,"Command error"

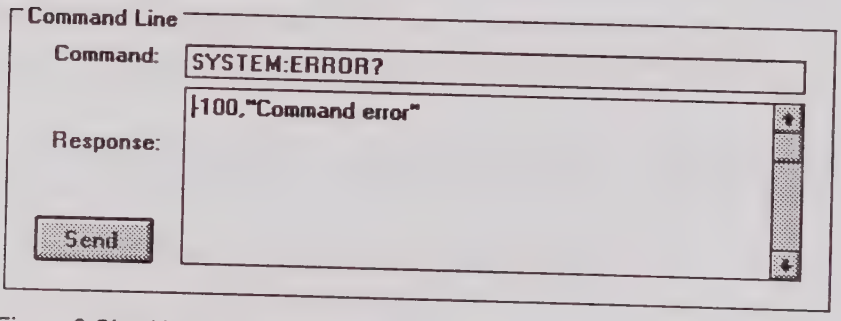


Figure 6 Checking for System Errors

5.1.4 Other commands

All other commands that can be issued from the command line are covered in Chapter 5 of the HGA instruction manual. Note however that the HGA GUI was not designed to handle all HGA query commands from the command line. A typical example of this is the 'TRACE:DATA?' query command. This command will result in a binary data stream from the HGA which cannot be handled properly by the Response text box in the Interface Setup screen. Commands like these are reserved for custom programming applications.,

1. Close the Interface Setup screen by clicking on the Close button in the bottom right corner.

6. Hardware Configuration

The HGA acts as the controller for the AC power source to which it is connected. In order to do so, it needs to know the capabilities of the connected power source with respect to voltage ranges, output power and frequency. This information resides in the HGA's non-volatile memory and can be queried by the HGA GUI program. The configuration data is determined by the hardware and can therefore not be altered from the HGA GUI program. This screen is accessed by selecting the **Configuration** menu item.

1. Click on the Configuration menu item to select the "Configuration Setup" screen.
2. Note that none of the controls can be changed. The information is provided only for review purposes.

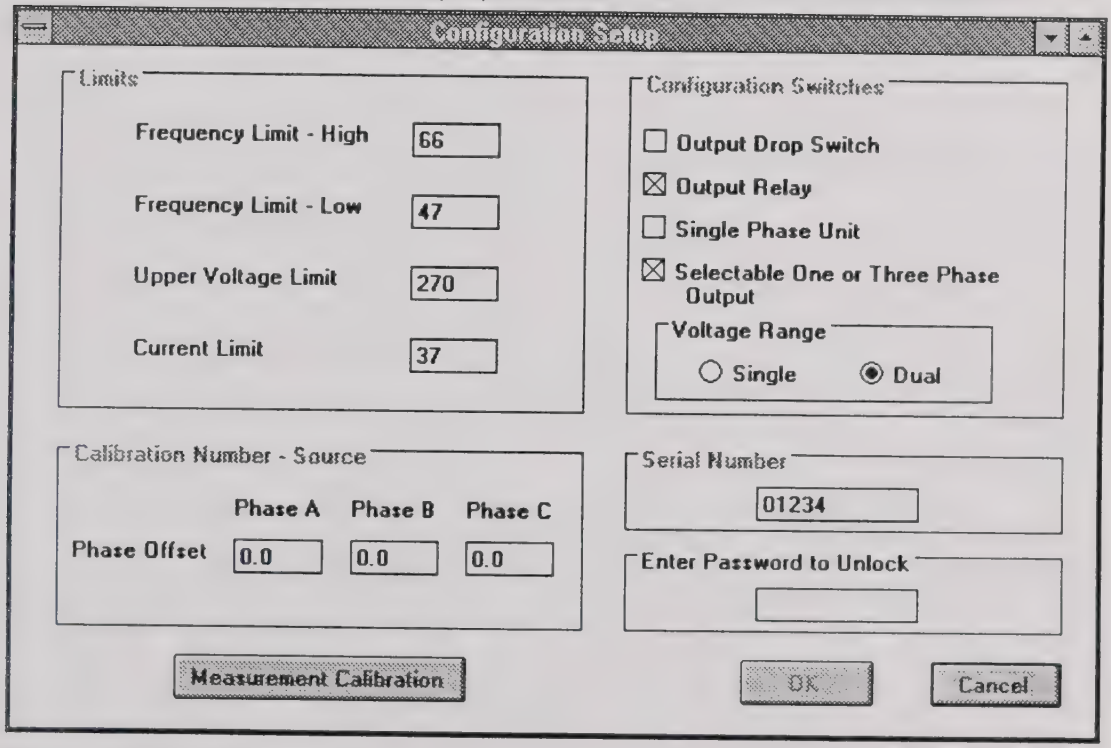


Figure 7 System Setup screen

The hardware configuration limits for frequency, voltage and current will be used by the HGA GUI to set limits for the various controls. Thus, it is impossible to set invalid values on the other HGA GUI screens.

This Configuration Setup screen also provides access to the Measurement Calibration menu which will be covered in a later section.

1. Click on the Cancel button to close the Configuration Setup screen.

7. Source Control

The source control menu is the primary control interface to the HGA. From the source controls, parameters such as voltage, frequency and current limit can be set and changed. It replaces the front panel of the HGA with a full screen graphical interface.

The Source Control is divided in three distinct areas :

- System Setup which allows you to set the initialization values. These values will become active any time the HGA is first powered up.
- Steady State which controls the momentary values of the source parameters. This is closet screen to an actual instrument front panel.
- Transient List Programming which allows the 16 HGA transient registers to be programmed and downloaded to the HGA for execution.

We will cover each of these three source control screens in sequence:

7.1 Source System Setup

The source system setup screen allows the user to set the initialization parameters of the AC source. It is accessed by pulling down the Source menu and selecting the first entry called System.

1. Click on the **Source** menu item in the main menu bar
2. Select the **System** entry. This should bring up the "Source System Setup" screen.

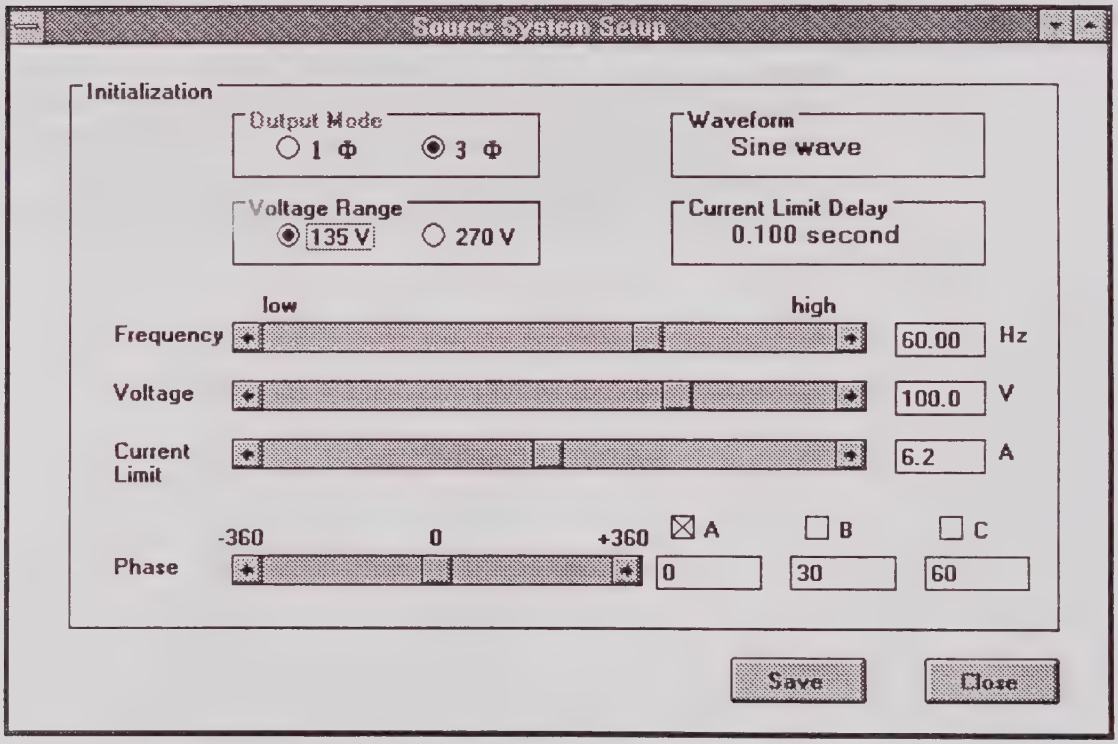


Figure 8 Source System Setup screen

Key parameters such as frequency, voltage and current limit can be changed using the three 'slider controls' in the center of the screen. The minimum and maximum values that you can set are determined by the Configuration Setup hardware limits.

7.1.1 Operating Slider Controls

Slider controls are best operated with the mouse. The value attached to the slider control can be decreased in small steps by clicking on the left arrow. It can be increased in small steps by clicking on the right arrow. To make larger changes, click to the left or the right of the slider marker to decrease or increase the value. To continuously change a value, click on the slider marker and hold down the left mouse button. You can now drag the marker to the left or the right to decrease or increase the value rapidly. Refer to figure 9 for a detailed look at the operation of a slider control.

Figure 9 : Slider control operation

7.1.2 Setting Initial Frequency, Voltage and Current Limit

1. Use the mouse to move the initial frequency value up or down. Set it at value that you want the power source to power up with next time you turn it on, e.g. 50 Hz.
2. Make sure the voltage range is set to 135 V
3. Use the mouse to slide the voltage to its maximum value. This value will be determined by the range. (135 in this case) ***Note that the same initial voltage will apply to all three phases at power on.***
4. With the voltage at the maximum value, change the voltage range selection and notice the position of the voltage slider change. The HGA GUI automatically tracks changes that affect each other.
5. With the voltage range set to 270 Volt, move the current limit slider all the way to the right to set it to its maximum value.
6. Now change the voltage range back to 135 Volt and notice the current limit value change to half its previous value. The slider position is still to the far right since this is now the maximum possible value for the current limit.

7.1.3 Setting Initial Phase Angles

Phase angles for each the phases in a three phase configuration can be set with respect to phase A or an external sync.

1. Use the mouse to put a check mark in all three phases. Default, only phase A is enabled.
2. With all three phases checked off, move the slider control to the right.
3. Notice how all three phases assume the same value.
4. Move the slider until all values read 240.
5. Now disable phase C by clearing the check mark.
6. Move the slider until phase A and B read 120
7. Disable phase B by clearing the check mark
8. Move the slider until phase A reads 0

7.1.4 Waveform and Current Limit Delay

Waveform type is fixed as Sine at start up as is the current limit delay of 0.1 seconds. These values are shown for reference only and cannot be changed by user.

7.1.5 Saving Initial Settings to HGA Memory

Any changes made to the initial settings do not take effect until they are saved to the HGA's non-volatile memory. This is accomplished by clicking on the '**Save**' button.

1. Set the initial voltage to a 'safe' value such as 5 Volts.

2. Press the Save button to save the new initial values.

Note that these values do not become active unless the HGA is powered down first. Do not confuse initial values with steady state values. (see next section)

7.1.6 Closing the Source System Setup screen

The '**Close**' button closes the Source System Setup screen and returns focus to Main program window. You must close this window in order to continue.

7.2 Steady State Control

The steady state control screen provides interactive control of HGA output parameters. It is accessed by pulling down the Source menu and selecting the second entry called Steady State.

1. Click on the **Source** menu item in the main menu bar
2. Select the **Steady State** entry. This should bring up the "Source System Setup" screen.

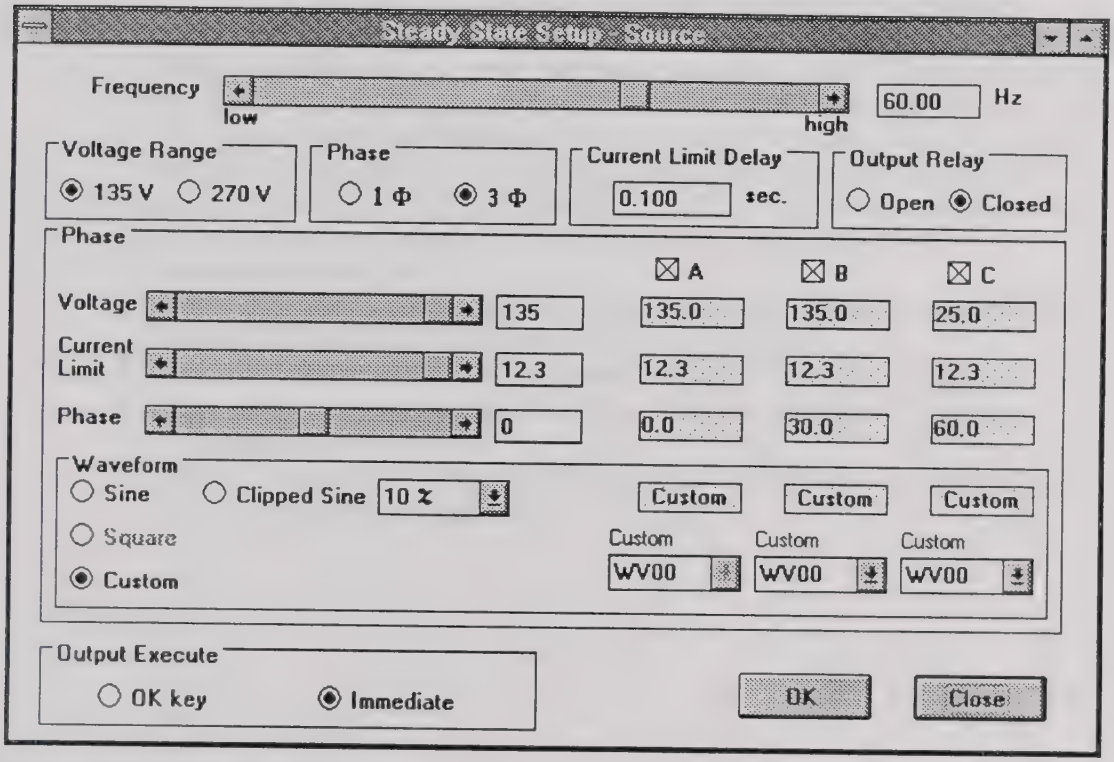


Figure 9 Steady State Setup screen

The Steady State Setup screen can be operated in one of two modes :

- Immediate Mode

  In the immediate mode of operation, changes made on the screen of the PC are immediately send to the HGA via the interface and take effect as they are changed by the user. This most closely resembles front panel operation.

- Button Execution Mode

  In the button execute mode of operation, changes made on screen are sent to the HGA as soon as the OK button is clicked. This allows you to make all changes first and update the HGA settings all at once.

The mode of operation is determined by the Output Execute option box in the lower left corner of the screen.

7.2.1 Slewing Output Frequency

When operated in the immediate mode, this screen can be used for manually slewing frequency, voltage and phase. To illustrate this capability, we need to be able to see the output of the AC source.

1. Connect two channels of the oscilloscope to phase A and phase B outputs of the AC source. If the oscilloscope you are using has three channels available, connect the third channel to phase C. Make sure the ground wires of the oscilloscope probes are connected to the Neutral. Be aware that most oscilloscope grounds are tied to earth ground so the AC source Neutral will be connected to ground through this connection.
2. Verify that the oscilloscope probes used are 10:1 and the scope can accommodate a 400 Vpp signal. This usually implies a 50 V/div attenuator settings.
3. Verify that the frequency of the signal shown on the scope matches the setting reflected by the Steady State Setup screen.
4. Use the mouse to drag the Frequency slider left and right. Observe the value of the frequency change on the PC screen as well as on the oscilloscope.
5. Notice the slight delay as the HGA receives, interprets and executes the continuous stream of commands from the PC.

7.2.2 Slewing Output Voltage

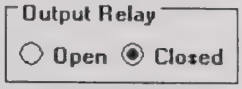
Slewing the voltage on the Steady State Setup screen is similar to turning the knob on the front panel of the HGA when the voltage immediate mode is selected. Unlike the frequency, output voltage can be set for each individual phase or for two or three phases at a time.

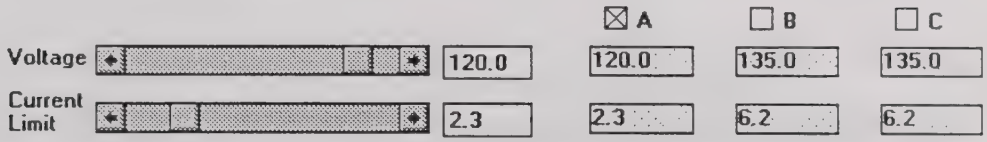
1. Select all three phases by putting a check mark at phase A, B and C.
2. Use the mouse to slew the voltage up and down and observe the amplitude change on the oscilloscope.
3. Switch to the High voltage range (270 Volt) and observe the output drop momentarily to zero volt. Switching ranges always causes the HGA to program all outputs to zero to avoid hot switching of relays. Once the range change takes place, the output voltage is set back to its previous value unless it exceeds the maximum voltage in the present range.
4. Verify this by setting the voltage to 200 Volt in the 270 Volt range and then switching to the 135 Volt range. Notice the output is now at 135 Volt.

7.2.3 Setting Current Limit

This exercise requires a load on at least one phase. If no load is available, skip this section.

1. Program the voltage down to zero volt for all three phases.
2. Open the output relay by clicking on Open in the Output Relay box located at the top right hand of the Steady State Setup screen.



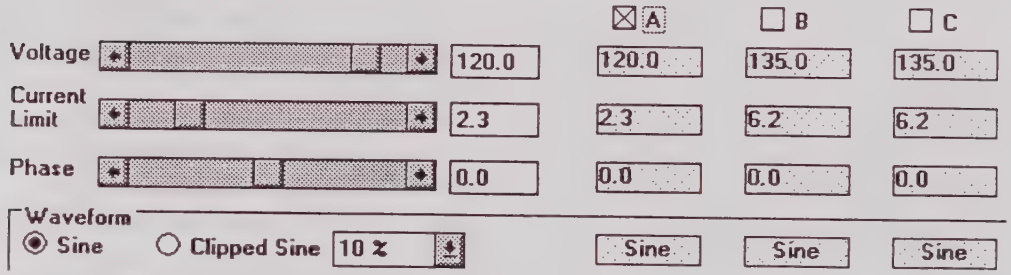


3. Connect a load to the output for phase A. Make sure the load does not exceed the capability of the AC power source used.
4. Close the output relay and set the output voltage to the desired value for the load.
5. Select only the phase to which the load is connected (Phase A) and slide the current limit value down gradually until it drops below the required current to drive the load.
6. Notice the output voltage drop to zero as soon as the current limiter kicks in.
7. Move the current limit up to turn off the current limiter and leave it set slightly above the load requirement.

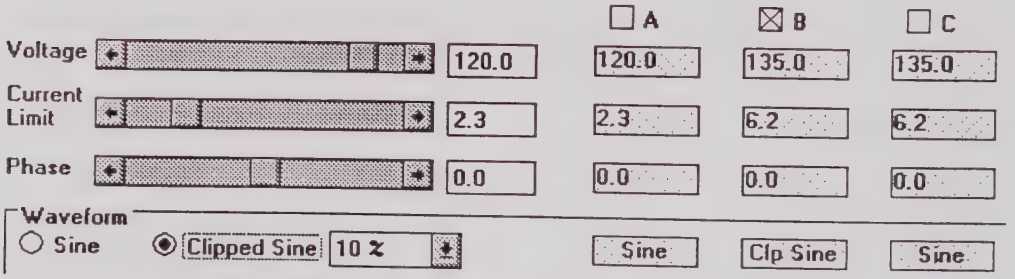
7.2.4 Selecting Waveform Shape

Depending on the capabilities of the AC power source used, waveforms other than a sinewave can be used to generate the desired AC output power. Specifically, Clipped sinewaves are available with most AC sources. This introduces a controlled level of distortion that can be used to test the susceptibility of a load to such phenomena.

1. Select phase A only



2. In the **"Waveform"** area of the Steady State Setup screen, click on the Sine option and verify on the oscilloscope that the output for phase A is indeed a Sine.
3. Deselect phase A and select phase B instead



4. Select Clipped Sine and set the amount of clipping to 10 %
5. Verify that the output of phase B is now distorted by having flat tops and bottoms.
6. Pull down the Clipped Sine drop-down list and increase the amount of clipping to 20 %. Observe the effects on the oscilloscope.
7. Now change the amount of clipping to 0 % and notice the identical waveforms of phase A and B.
8. Return phase B back to a regular Sine waveform.

7.2.5 Setting all Parameters at Once

The Button Execute mode allows all parameters of the HGA to be updated at once.

1. Select the button execute mode by clicking on the OK key option in the Output Execute field located in the bottom left corner of the Steady State Setup screen.
2. Set the parameters as reflected in figure 10.
3. Press the OK button in the lower right hand side corner and observe the output of the oscilloscope. All settings are updated as soon as the OK button is pressed.
4 This mode of operation is preferable if many parameters have to be changed at once such as when switching to a new application.

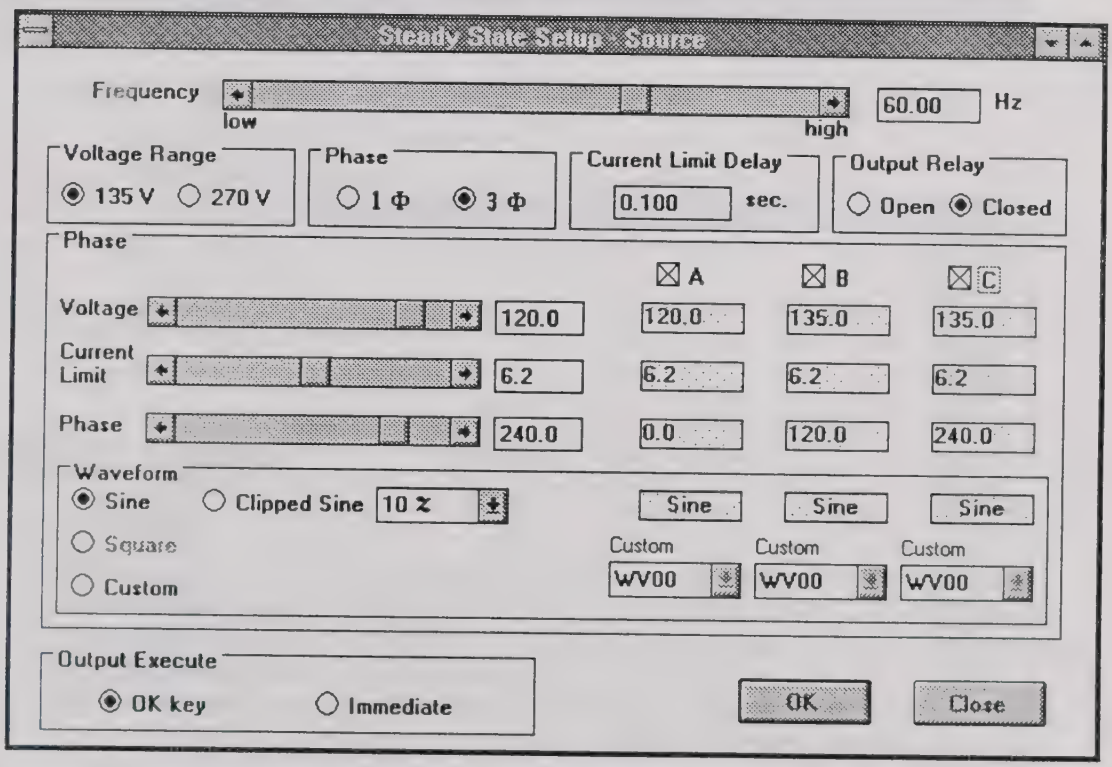


Figure 10 Changing all Steady State values using the OK button

5. Close the Steady State Setup screen by clicking on the Close button. This will return focus to the Main program window.

7.3 Transient Programming

Transients are an important aspect of AC power testing and the HGA offers powerful capabilities for this type of application. Transients are programmed by setting one or more of the 16 transient steps and recalling them under program control. More than one step can be executed in sequence to create complex sequences of events.

The list of Transient steps can be programmed using the Source Transient List screen which is located in the Source menu.

1. Click on the **Source** menu item in the main menu bar

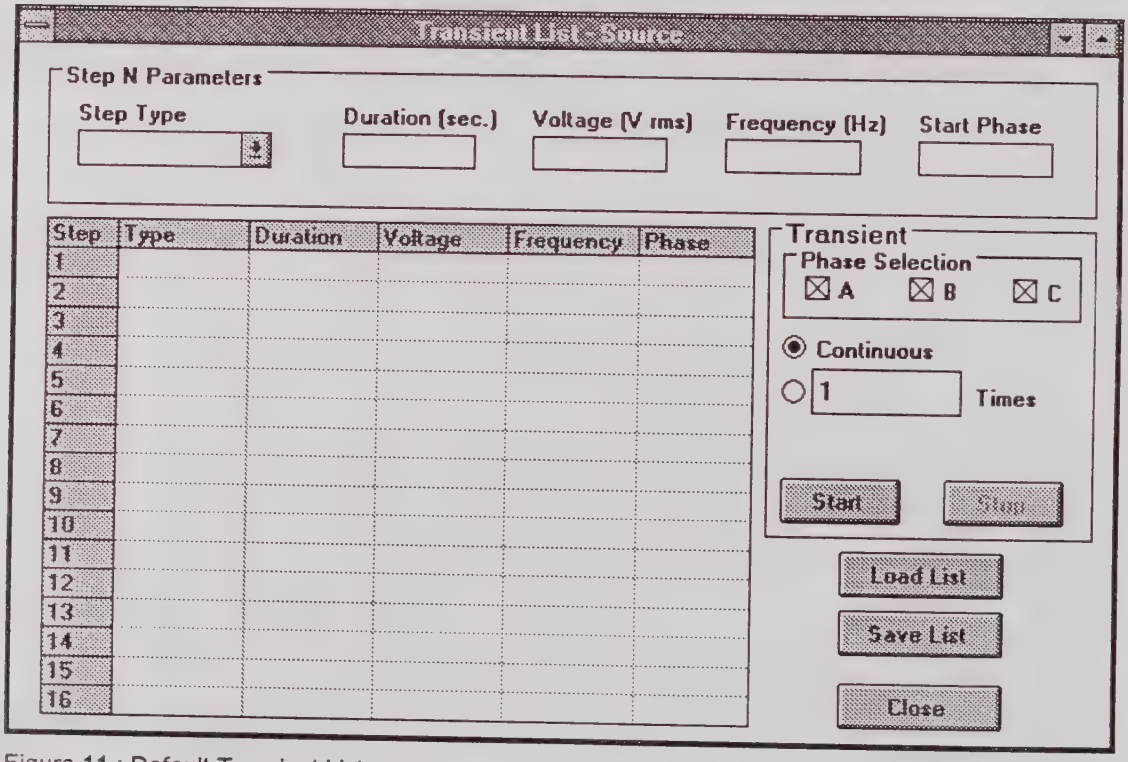
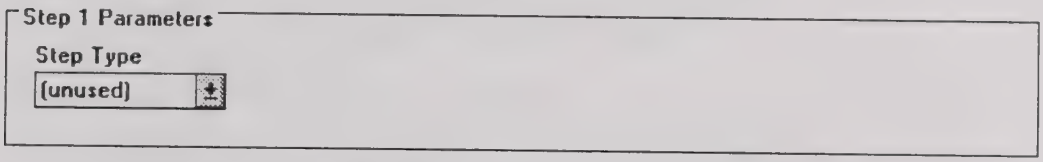


Figure 11 : Default Transient List screen

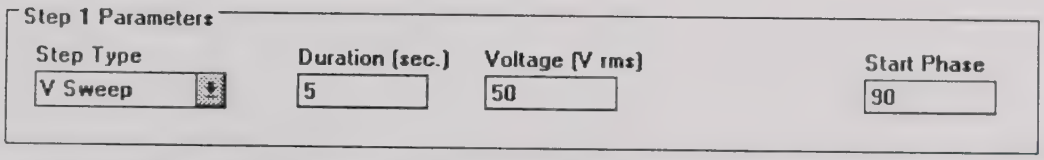
2. Select the **Transient** entry. This should bring up the "Transient List" screen.

The Transient List screen consists of a grid with sixteen rows, one for each transient step. The contents of each row can be edited in the edit box at the top of the screen. A transient step can operate on one phase, two phases or all three phases at the same time. This is determined by the Transient phase selection box on the right hand side. Transient execution is also started from this screen. You have a choice between continuous execution mode where the transient program is run repetitively or executing the transient program N number of times.

Programmed transient sequences can be saved to the PC disk for future recall. This allows you to create many libraries of transient test sequences. In this exercise we will develop a transient sequence, save it to disk and then execute it and observe the results on the oscilloscope. To observe some transients, it may be advantageous to have a digital storage oscilloscope with single shot capability as opposed to an analog oscilloscope.



7.3.1 Programming a Voltage Transient Step



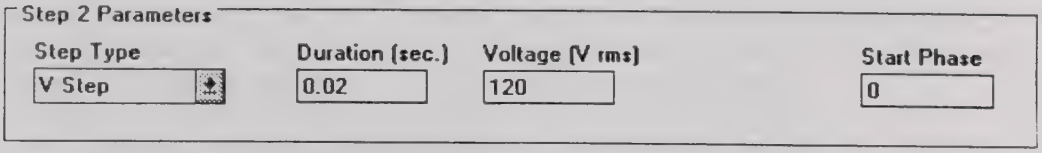
The first step in programming a transient step is to select the step you want to program. Default, this screen appears as shown in figure 11 with Step N shown in the edit box. This is merely a reminder for you to select an actual step number before attempting to program it.

1. Click on the first row (row 1) in the grid. Observe the edit box change to "Step 1 Parameters". Also, only the first edit field is visible and reflects the fact that this step is currently empty. (unused)
2. Use the drop down list to select V Sweep. (Voltage sweep). Three new edit boxes appear allowing you to enter duration, voltage and starting phase angle.
3. Enter the values shown below to complete programming of register/step 1

Let's review the meaning of each parameter. V Sweep implies that we will gradually change the voltage (amplitude) from its present value, (determined by the steady state setting or the end value of the previous transient step if there was one) to an **end** value of 50 Vrms. The time for this step to execute is set at 5 seconds. Thus, in our case with the steady state voltage set at 120 Vrms, the voltage will gradually decrease from 120 to 50 Volt over a 5 second period. The smallest amount of time we can program is 0.002 seconds or 2 milliseconds. The largest amount of time we can program is 300 seconds or 5 minutes. The start angle will be 90°.

Of course, the voltage at the end of this step will be at 50 Vrms so if we executed this sequence more than once, the second time it is executed it would have no effect on the output since it would sweep from 50 V to 50 V in 5 seconds. Therefore, we need another step to bring the voltage back up to its nominal level of 120 V.

1. Click on the second row in the grid to select step 2.
2. Enter the parameters shown below for step number 2.



This will cause the voltage to step from the previous step's end value (50 Volt in our case) to 120 V after 0.02 seconds. This is done as quickly as possible or 20 milliseconds after the end of step 1 starting at a 0° phase angle.

With these two steps programmed, we can observe the effects of our little transient program by running it.

1. Select the N times execution mode by clicking on the second option in the Transient box on the right hand side of the screen.
2. Enter '1 Times' if this value is not already shown
3. Click on the Start button.
4. Observe the HGA GUI downloading the current step list to the HGA and then executing it once.
5. Look at the scope to see the impact of this program. The voltage for all three phases should gradually drop to 50 Vrms (142 Vpp) and then return quickly to 120 Vrms (342 Vpp)

7.3.2 Programming a Frequency Transient Step

We will expand on our previous transient program by changing the frequency for a short duration. From our steady state setup screen, we know the nominal frequency is set at 60 Hz. Let's try to drop the frequency to 45 Hz for a period of 2 seconds (long enough to see on the oscilloscope screen) and then bring it back up to 60 Hz quickly. Much like the voltage transient, we need two steps for this purpose. Only this time, we will step the frequency to 45 Hz instead of sweeping it.

1. Click on step 3 and select F Step
2. Program a 2 second duration and a 47 Hz value. This means the frequency will change to 47 Hz at the beginning of this step and remain there for 2 seconds. After 2 seconds, the next step will execute. If there is no next step, the frequency will remain at 47 Hz.
3. Our objective was to return the frequency to 60 Hz again so we need to add a F Step in step 4. Use 60 Hz as the step value and a duration of 0.02 seconds.

Your Step grid should look like the one shown below.

Step	Type	Duration	Voltage	Frequency	Phase
1	V Sweep	5.000	50.0		90.0
2	V Step	0.020	120.0		0.0
3	F Step	2.000		47.00	
4	F Step	1.000		60.00	
5					

4. Run the transient program once by clicking on the Start button.
5. Observe the jump in frequency that occurs at the end of the program.

Notice the difference between a sweep and a step. For a sweep, you set the end value or the value to reach at the end of the sweep which is also the end of the step. For a step, you set the value to go to. This means, the AC source will step to this value immediately. After the duration period expires, the next step in the list is executed.

7.3.3 Combined Voltage and Frequency Sweeps

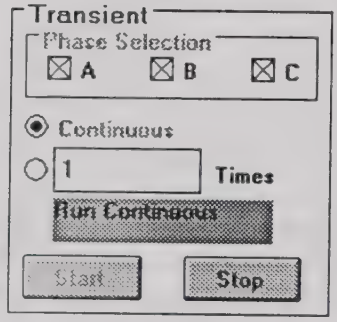
Voltage sweeps and Frequency sweeps can be combined into a single step using the VF Sweep function. We will use a VF Sweep as the last step of our transient program.

1. Select Step 5
2. From the Step Type drop down list, select the VF Sweep step. (last one in the list)
3. Set the duration to 3 seconds, end voltage to 135 Volt and end frequency to 66 Hz. Set the start phase angle to 90°.

Your grid should look like the one shown below.

Step	Type	Duration	Voltage	Frequency	Phase
1	V Sweep	5.000	50.0		90.0
2	V Step	0.020	120.0		0.0
3	F Step	2.000		47.00	
4	F Step	1.000		60.00	
5	VF Sweep	3.000	135.0	66.00	0.0
6	(unused)				

4. Change the execution mode to continuous and click on the Start button

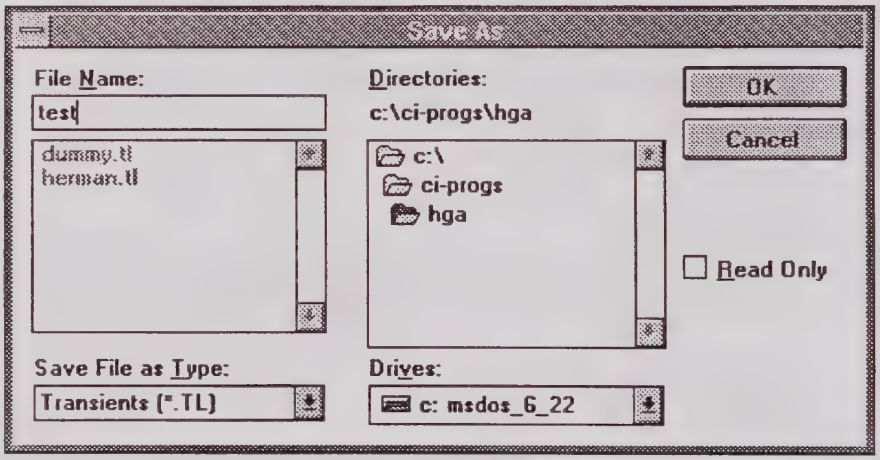


4. Observe the effect of the entire transient program which repeats every 11.02 seconds.
5. Click on the Stop button to stop the program

7.3.4 Saving Transient Programs

Transient programs can be saved to disk for future recall. This is accomplished by clicking on the "Save List" button. You will be asked for a filename under which to save this list of transient steps. Do need exceed the 8 character DOS filename limit.

1. Click on the "**Save List**" button. A File Save As... dialog box will appear.
2. Enter a file name of eight characters or less in the File Name box, e.g. "TEST". A filename extension will be added automatically. Transient list files use ".TL" as the file type extension.



If you want to save transient lists in a different directory, you can use the Directories: portion of the File Save As... dialog box. Default, the transient list files will be saved in the same directory as the HGA GUI program.

3. Click on the OK button to close the dialog box and save the transient list.

Opening a previously saved transient list is done in a similar way using the "Load List" button.

This concludes the Transient portion.
Click on the Close button to close the Transient List screen and return to the Main program screen.

8. Generating Harmonic Waveforms

The ability to generate harmonically distorted waveforms is one of the key capabilities of the HGA controller. This requires the use of the HGA GUI for generating and downloading waveform data to the 18 arbitrary waveform registers available in the HGA.

The harmonics program screen is accessed from the Custom Wave menu.

1. Use the mouse to pull down the "Custom Wave" menu on the main menu bar.
2. Select the "**Harmonics**" entry.
   The Harmonic Generation screen should be visible now.

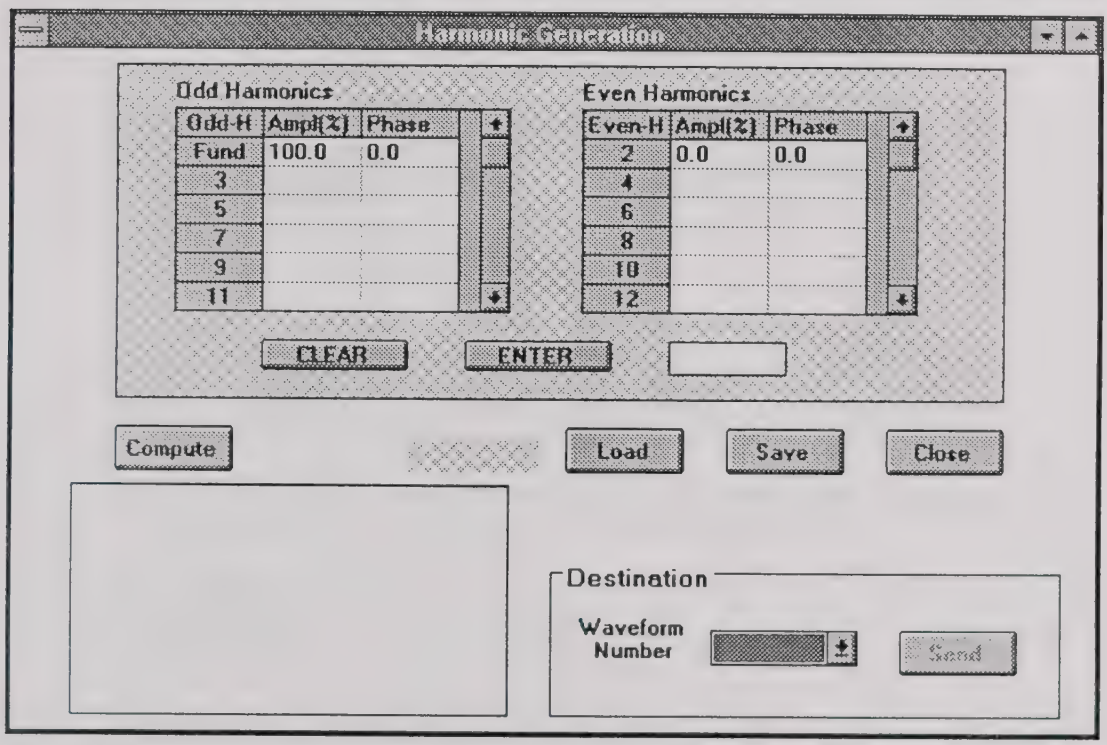


Figure 12 : Harmonic Generation screen

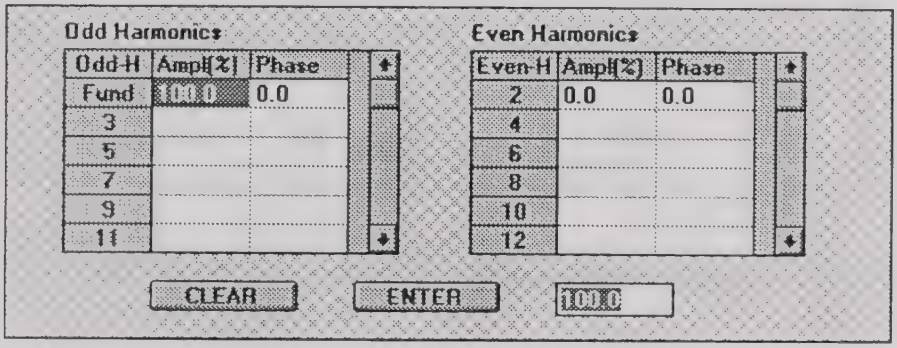
Harmonic voltage waveforms are defined by their harmonic contents using one table for the odd harmonics and a second table for the even harmonics. Each harmonic of the fundamental frequency has a relative amplitude expressed in percentage associated with it as well as a phase angle. This allows any type of harmonic voltage waveform distortion to be defined.

Once table values for various harmonic components of a waveform are entered, the resulting waveform shape can be shown by clicking on the "Compute" button. Harmonic waveform tables can also be saved to and loaded from the PC disk. This allows the user to create a library of commonly used waveforms.

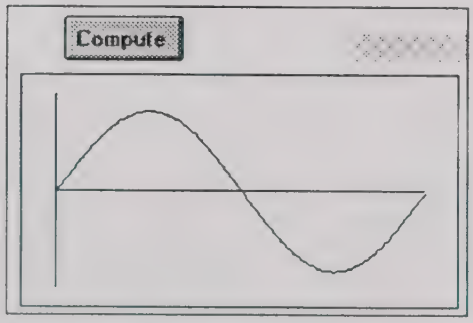
8.1 Synthesizing a Harmonically Distorted Waveform

We will illustrate the use of HGA GUI by creating a simple harmonically distorted waveform.

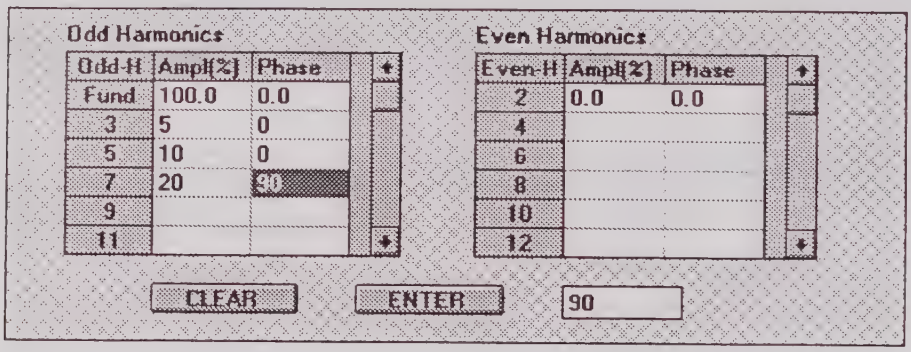
1. Select the first cell in the "Odd Harmonics" table labeled Fund (Fundamental frequency)
2. In the data entry box that is highlighted now, enter 100 for 100 %.
3. Click on the "ENTER" button to accept your data entry. You can also use the Enter key on your keyboard.
4. Click on the Phase cell for the Fundamental and enter 0°.



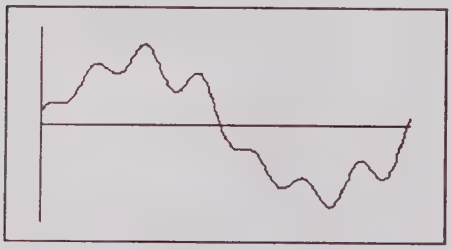
5. To see what this waveform would look like, click on the "Compute" button and observe the result. A pure, undistorted waveform.



6. Add some harmonic content by adding additional odd harmonic components as shown in the table below.



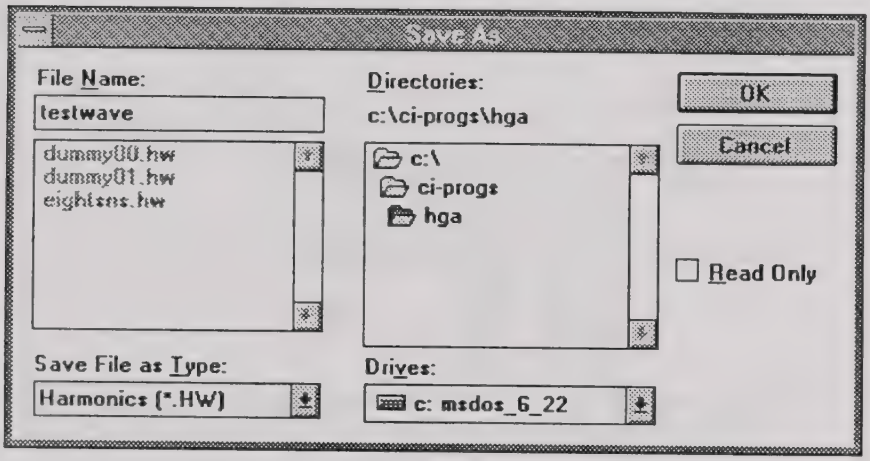
7. Analyze the synthesized waveform by clicking on the "Compute" button. Your waveform should look like the one shown below. Note that this is a very extreme example. Waveforms found in most applications are nowhere near this level of distortion.



8.2 Saving Harmonic Tables

Harmonic tables created with the HGA GUI can be saved to disk for future use. This allows you to create a library of waveforms.

1. Click on the "Save" button. This will bring up the "Save As..." dialog box.
2. Enter a name for the waveform you have just created of no more than eight characters. For example, use "testwave".
3. A filename extension ".HW" will be added automatically. (HW = Harmonic Waveform). These files can only be used by the HGA GUI program.



4. Click on the "OK" button to save this waveform data.
5. Notice that the name you just gave the waveform now appears to the right of the "Compute" button.

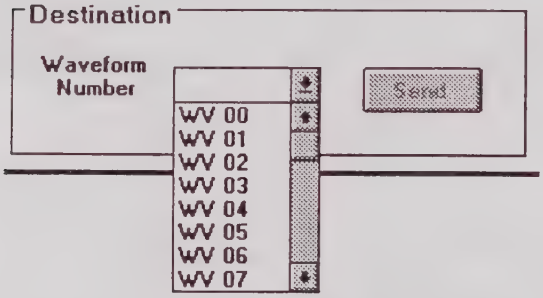
Loading of previously saved harmonic waveforms is accomplished the same way. Use the "Load" button to obtain the Load dialog box and select a waveform from the list shown.

8.3 Downloading Waveform Data to the HGA

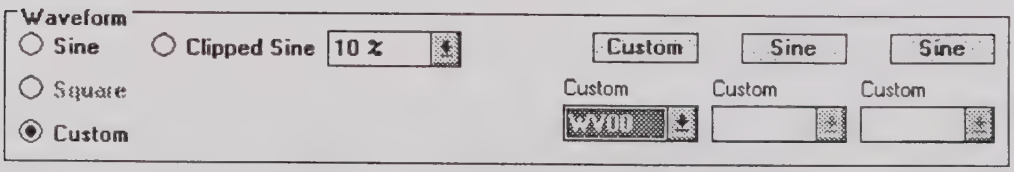
The HGA has a total of 18 non-volatile arbitrary waveform registers that can accept harmonic waveforms. This allows 6 different waveforms for each phase in a three phase system to be downloaded. In a single phase system, all registers can be used by the same phase.

To download waveform data from the HGA GUI to the HGA, you must first select a destination register. Registers are numbered WV 00 through WV 17.

1. Click on the drop down list in the Destination area at the lower right corner of the Harmonic Generation screen.



2. Use the mouse to select the first available register. (WV 00)
3. Once a destination register has been chosen, the "Send" button is enabled.
4. Click on the Send button to download the waveform data.
5. This process can take several seconds when using the RS232C interface.
6. The waveform will not appear at the output immediately since we have not selected it in the Steady State Setup screen.
7. Click on the "Close" button to close the Harmonic Generation screen and return to the Main program screen.
8. From the "**Source**" menu, select "**Steady State**"
9. Make sure only phase A is checked in the "Phase" box
10. In the "Waveform" section of the screen, select **Custom**
11. In the Custom drop down list for Phase A, select "**WV 00**"



Notice the change in the shape of the output waveform that occurs as soon as you select WV00.

12. Click on the "Close" button to remove the Steady State screen and return to the Main program screen.

NOTE : The download waveform will remain in the HGA's non-volatile waveform memory until deleted or overwritten by new waveform data.

9. HGA GUI Measurements

Measurements are an integral capability of the HGA and the HGA GUI program allows you to access and display all the measurement capabilities of the unit. This extends beyond the voltage, frequency, current and power measurements that can be done from the front panel.

Due to the amount of information available from the HGA measurement suite, the measurements have been divided into four separate screens. They are :

- Basic Measurement I
- Basic Measurement II
- Harmonics - Current
- Harmonics - Voltage

Each set of measurements will be covered individually

9.1 Basic Measurement I

This set of parameters involves the standard measurements of voltage (rms), current, frequency and true power. Measurements are available for all three phases and phase angles are measured as well.

To perform these exercises, it is important to have a load connected. We will concentrate on phase A only since all measurement types are the same, regardless of the phase.

1. Make sure your load is still connected to the Phase A output. If not, connect is as described in section 7.2.3
2. Use the mouse or keyboard to select the **Measure** menu from the main menu
3. Choose the first entry called "**Basic Measurement I**"

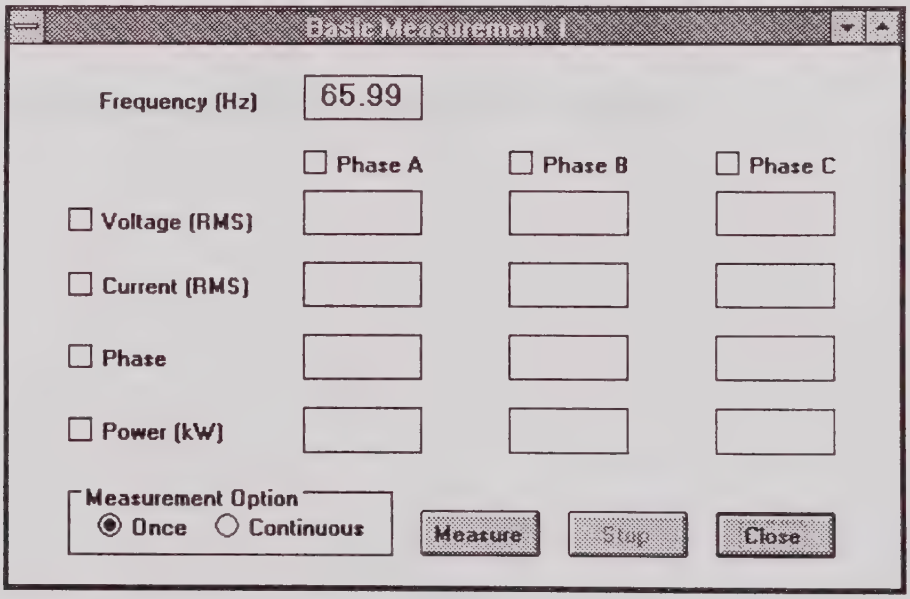


Figure 13 : Basic Measurement I

The first measurement screen will appear.

4. Select only phase A by clicking on the check box. If there is a check mark in front of phase B and/or C, remove it by clicking on the relevant check box.
5. Put check marks in front of all four categories of measurements.
6. Make sure the Measurement Option "**Once**" is selected at the bottom of the screen.
7. Click on the "Measure" button to start the measurement process

Notice the green indicator that appears in front of the measurement value box as each measurement is requested from the HGA.

Performing all measurements can take several seconds. When the green indicator disappears, all measurements are completed. Actual values that appear are dependent on the current HGA settings and the nature of the load that is present.

9.2 Keeping Measurements on screen

All four Measurement screens are non-modal. This means that you can leave the four measurement screens open at all times while you are accessing one of the other GUI screens or even another Windows™ program. Let's illustrate this by using the Basic Measurement I screen

1. Select the Continuous mode in the Measurement option box.
2. Press the "**Measure**" button to start updating the readings.
3. Resize the "**Basic Measurement I**" window so you can still see the readings for phase A and move the window to the side of the screen.
4. Click on the "**Main program**" window. The Basic Measurement I screen should still be visible.

If your monitor is too small to show sufficient portions of the Basic Measurement I screen, you can use the mouse to resize the Main program window and make it smaller.

5. Now open the Steady State Setup screen located in the **Source** menu.

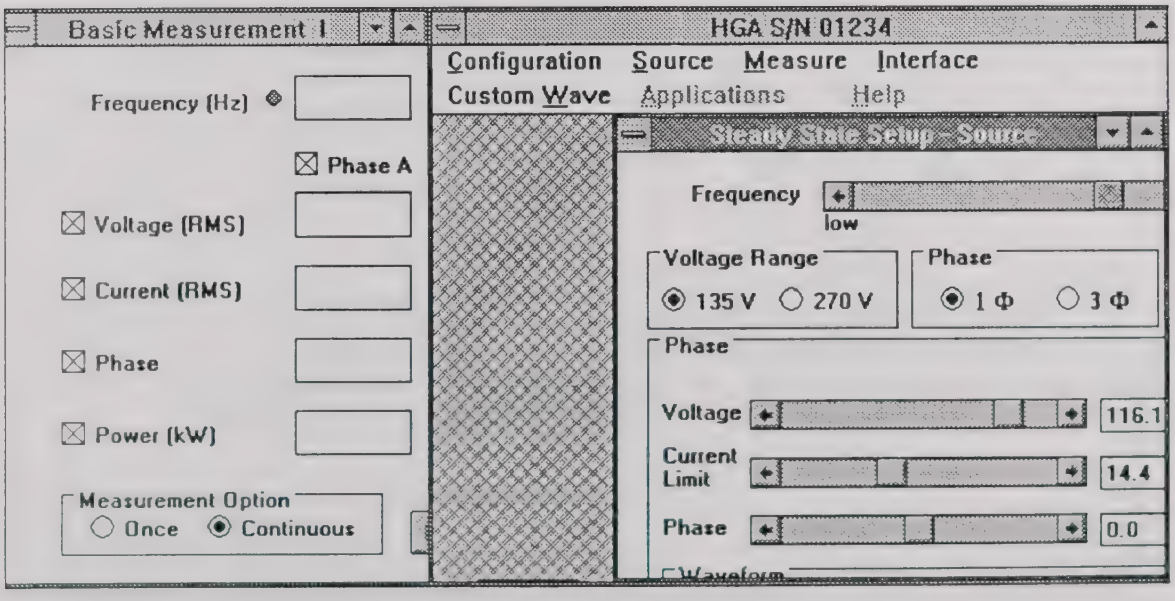


Figure 14 : Changing settings while monitoring measurements

6. Make this window smaller and move it out of the way if it obstructs the Measurement window.
7. Adjust the frequency up and down and observe the readings in the Measurement window.
8. Do the same with the Voltage adjustment.

Note that you cannot exit this window by clicking on another window as this is a modal window. You must Close this window to return to the Main program window.

9. Click on the Close button when done to return to the Main program screen.

You may have to scale the "**Steady State Setup**" window back to its original size in order to locate the Close button.

9. Click on the "**Basic Measurement I**" window to bring it in focus. You can now close this window by clicking on the Close button.

You may have to scale the "**Basic Measurement I**" window back to its original size in order to locate the Close button.

9.3 Basic Measurement II

The second set of basic measurements involves the following parameters :

- Peak current[1]
- Power Factor
- Apparent Power (kVA)
- Total harmonic distortion for both current and voltage. These measurements are made with respect to the fundamental frequency

1. Use the mouse or keyboard to select the **Measure** menu from the main menu
2. Choose the second entry called "**Basic Measurement II**" The second measurement screen will appear.
3. Select all five measurements for Phase A.
4. Click on the "Measure" button to start a measurement cycle.
5. Click on the Close button when done to return to the Main program screen.

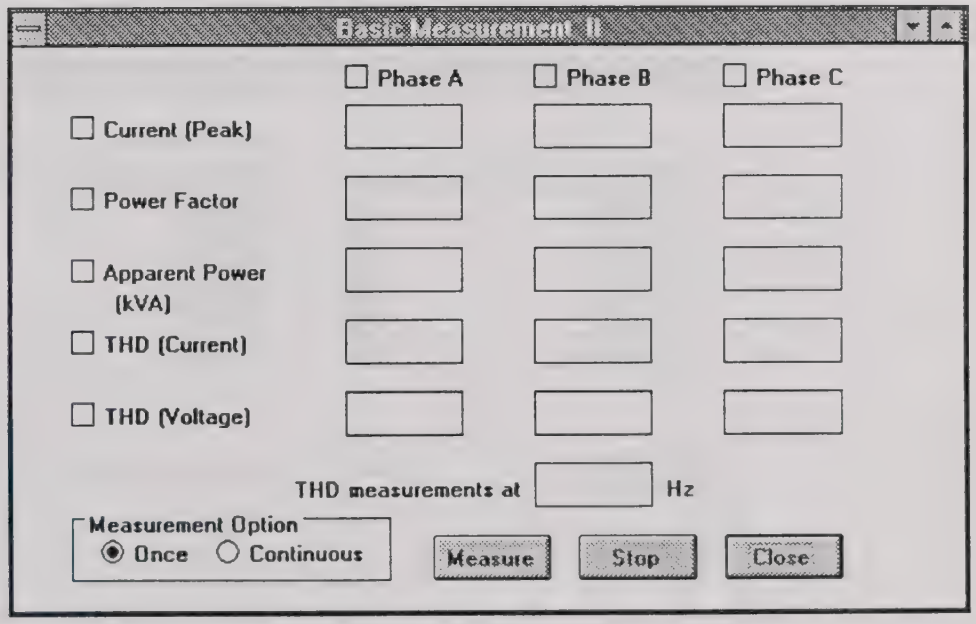


Figure 15 : Basic Measurement II screen

[1] The Peak Current measurement tracks maximum momentary load current. It is reset to zero each time the "Measure" button is clicked. To determine peak inrush current, start Basic Measurement II and then close the Output relay from the Steady State Setup screen.

9.4 Harmonics - Current Measurements

Harmonic current measurements provide useful information concerning the nature of the load. Higher order harmonics occur primarily when loads are non-linear.

Harmonic measurements can be made for one phase at a time. In our exercise, we will focus on phase A since the operations are identical no matter what phase is being measured. These measurements return absolute and relative amplitude of the load current for all odd and even harmonics of the fundamental frequency up to the 51st. To accommodate all this information, the HGA GUI uses a set of two grids not unlike those found in the Harmonics Generation screen.

Since the voltage waveform we are putting out contains higher order harmonics, we should be able to measure the current harmonics even if the load is linear.

1. Pull down the "**Measure**" menu.
2. Select the "**Harmonic Current**" entry

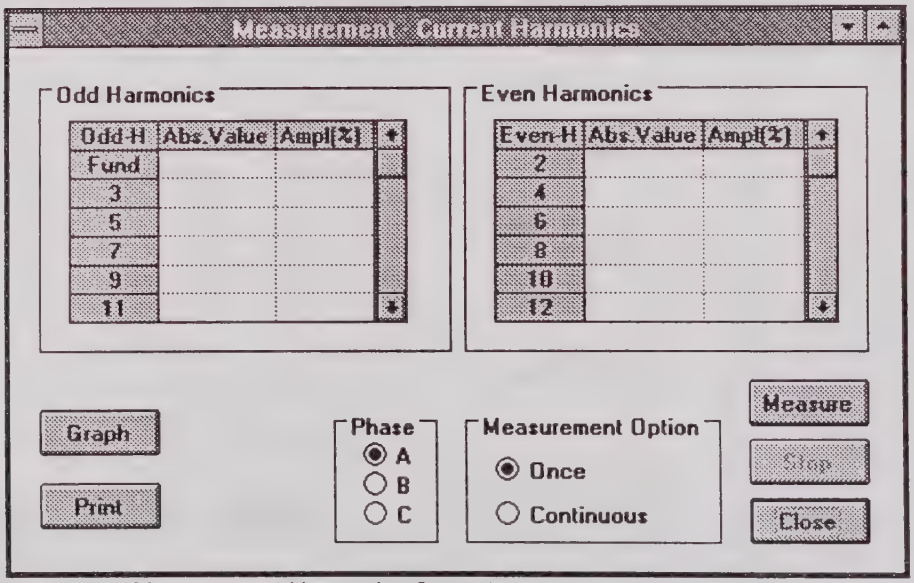


Figure 16 : Measurement Harmonics Current

3. Make sure phase A is selected
4. Click on the "Measure" button and wait for the measurement cycle to complete
5. Click on the "Graph" button to show a graphic representation of the current harmonic content.

6. Click on the "Close" button until you are back at the Main program screen.

9.5 Harmonics - Voltage Measurements

Like before, we will focus on phase A since the operations are identical no matter what phase is being measured. These measurements return absolute and relative amplitude of the output voltage for all odd and even harmonics of the fundamental frequency up to the 51st. To accommodate all this information, the HGA GUI uses a set of two grids not unlike those found in the Harmonics Generation screen.

Since the voltage waveform we are putting out contains higher order harmonics, we should be able to measure them.

1. Pull down the "**Measure**" menu.
2. Select the "**Harmonic Voltage**" entry

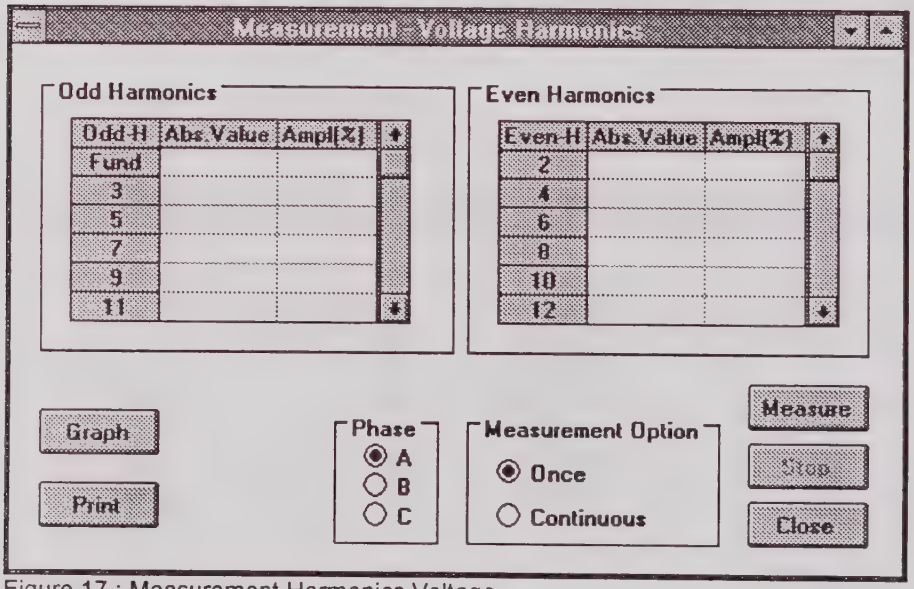


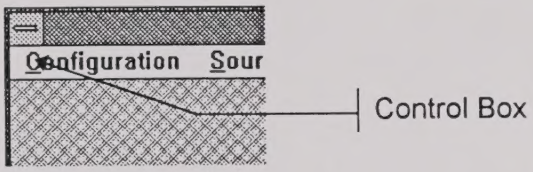
Figure 17 : Measurement Harmonics Voltage

3. Make sure phase A is selected
4. Click on the "Measure" button and wait for the measurement cycle to complete
5. Click on the "Graph" button to show a graphic representation of the voltage harmonic content.
6. Click on the "Close" button until you are back at the Main program screen.

10. Exiting the HGA GUI

The HGA GUI can be exited only from the Main program window in one of three ways :

1. By double clicking on the control box. The control box is located in the top left hand corner of the Main program window.



2. By clicking on the control box once to pull down the system menu and selecting the "**Close**" entry.
3. By holding down the ALT key and pressing the F4 function key.

Upon exiting the program, the HGA GUI will write information concerning the type of interface and interface parameter settings to disk (setup.dat). This allows it to locate the HGA when started up again. If the interface parameters change, be sure to enter the correct settings in the Interface Setup screen. (Refer to section 5)

Do not remove or alter the "setup.dat" file located in the same directory as the HGA GUI program.

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